

INSTRUMENTATION AND FLIGHT REPORT ON AEROBEE FLIGHTS 4.107 GE AND 4.108 GE

GPO PRICE \$ _____

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Hard copy (HC) 3.00Microfiche (MF) .75BY
J. W. CAMERON

N65 17260

(ACCESSION NUMBER)

74

(PAGES)

TMX-55127

(NASA CR OR TMX OR AD NUMBER)

(THRU)

1

(CODE)

14

(CATEGORY)

FEBRUARY 1965



GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

INSTRUMENTATION AND FLIGHT REPORT ON
AEROBEE FLIGHTS 4.107 GE AND 4.108 GE

By

J. W. Cameron

National Aeronautics and Space Administration
Goddard Space Flight Center

X-671-65-55

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ABSTRACT

This report, issued by GSFC's Sounding Rocket Instrumentation Section, contains all pertinent engineering data on actual flight instrumentation and describes the flight of two Aerobee 150 payloads. The purpose of these flights was to gather scientific information on very low energy cosmic ray heavy nuclei, using a recoverable payload. Intention of the report is to illustrate the function and performance of instrumentation supplied by this Section and not to present an analysis of either data or vehicle performance.

SUMMARY

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This report is one of a series issued by the Sounding Rocket Instrumentation Section. Contained is pertinent engineering information concerning the instrumentation and results of Aerobee Flights 4.107 GE and 4.108 GE.

Scientific objectives of these payloads were to study the very low energy cosmic ray heavy nuclei, using a recoverable payload.

It is the intention of this report to illustrate the function and performance of instrumentation and telemetry equipment supplied by the Sounding Rocket Instrumentation Section, and not to present an analysis of either scientific data or performance of the vehicle.

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INSTRUMENTATION AND FLIGHT REPORT ON AEROBEE FLIGHTS 4.107 GE AND 4.108 GE

INTRODUCTION

Activities described in this report detail the function of NASA/GSFC's Sounding Rocket Instrumentation Section, in support of Aerobee 150 Flights 4.107 GE and 4.108 GE. These flights were launched on 23 and 25 July 1964 (respectively) from Churchill Research Range, Fort Churchill, Manitoba, Canada.

Acknowledgement is made to John Rast of Sounding Rocket Branch's Engineering Section for design and development of the Extend/Retract Control assemblies, discussed in this report.

Primary purpose of the payload was to study the very low energy cosmic ray heavy nuclei by extending three large sheets of nuclear emulsions from the payload after the rocket was passed through the major portion of the atmosphere. Emulsion trays were retracted before re-entry. The experiment was contained in a recoverable payload in order to analyze the emulsions' reactions to the nuclei at a later date. Specifically, the basic experimental objectives were to:

1. Measure the flux and energy spectra of heavy nuclei in the very low energy region, above altitudes attainable with free balloons.
2. Measure the composition and relative abundance of heavy nuclei in the low energy region.
3. Study the ratio of light-to-medium-to-heavy nuclei in the low energies.
4. Measure the energy spectrum of alpha particles at low energies and compare this with the energy spectra of protons.

RESPONSIBILITIES

A pre-shoot conference was held at GSFC's Beltsville, Maryland facility on 15 January 1964. The areas of responsibility pertaining to the support of this experiment and, in particular, the responsibilities of the Sounding Rocket Instrumentation Section, were discussed and defined. (NOTE: Most of these commitments were nearly identical to those of a prior and similar experiment flown on Aerobee 150 Flight 4.91 GE.) Responsibilities of Sounding Rocket Instrumentation Section were to design, build, provide, and integrate an instrumentation system to be compatible with the scientific experiment, operations, and range requirements. The instrumentation system consisted of a five-channel, FM/FM telemetry system with associated antennas, battery power, control (timing and regulation), and calibration circuitry. In addition, Sounding

Rocket Instrumentation Section provided power and control functions (extend/retract) via the telemetry system. Input transducers for each payload included: a longitudinal and a transverse magnetometer, providing spin and tumble data; an accelerometer; a pressure gage and pressure switch, both of which were flown only on Flight 4.107 GE. S-band radar beacon antennas were also provided by Sounding Rocket Instrumentation Section. The radar beacon, an AN/DPN-41, was provided and installed by the Range, and was used to aid in radar tracking of the vehicle.

Sounding Rocket Instrumentation Section also provided the payload control panel, umbilical sections, field support equipment, and personnel for both payloads.

PERSONNEL

Dr. C. E. Fichtel, from the GSFC Energetic Particles Branch of the Space Sciences Division, was the Project Scientist. Aiding Dr. Fichtel and representing Sounding Rocket Instrumentation Section were L. C. Castagnola, Telemetry Engineer (later relieved for other commitments); J. W. Cameron, Telemetry Engineer (replacing L. C. Castagnola); and J. Ducosin, Payload Technician. Pan American's J. Contreras was the Range Project Engineer at Fort Churchill.

PAYLOAD

Figure 1 illustrates the configuration of Flights 4.107 GE and 4.108 GE. The payload consisted of a standard Aerobee ogive nose cone covering the instrumentation and telemetry rack, a 15-inch extension containing the experiment nuclear emulsion trays, and the parachute recovery system contained in a second 14.75-inch extension. Attachment of the payload to the vehicle sustainer was made through a severance ring containing the prima cord separation system.

Instrumentation mounted in the sustainer's regulator and tail can sections were connected via the shroud lines.

INSTRUMENTATION

Where weight, space, and telemetry channel allocations are not critical, Aerobee flights are instrumented to provide definitive vehicle performance and housekeeping information. Since Flights 4.107 GE and 4.108 GE were not critical in any of these areas, it was possible to include a thrust accelerometer, and longitudinal and transverse magnetometers. A thrust chamber pressure gage and pressure switch were also flown on 4.107 GE, but not on 4.108 GE. The pressure switch was a new device, installed

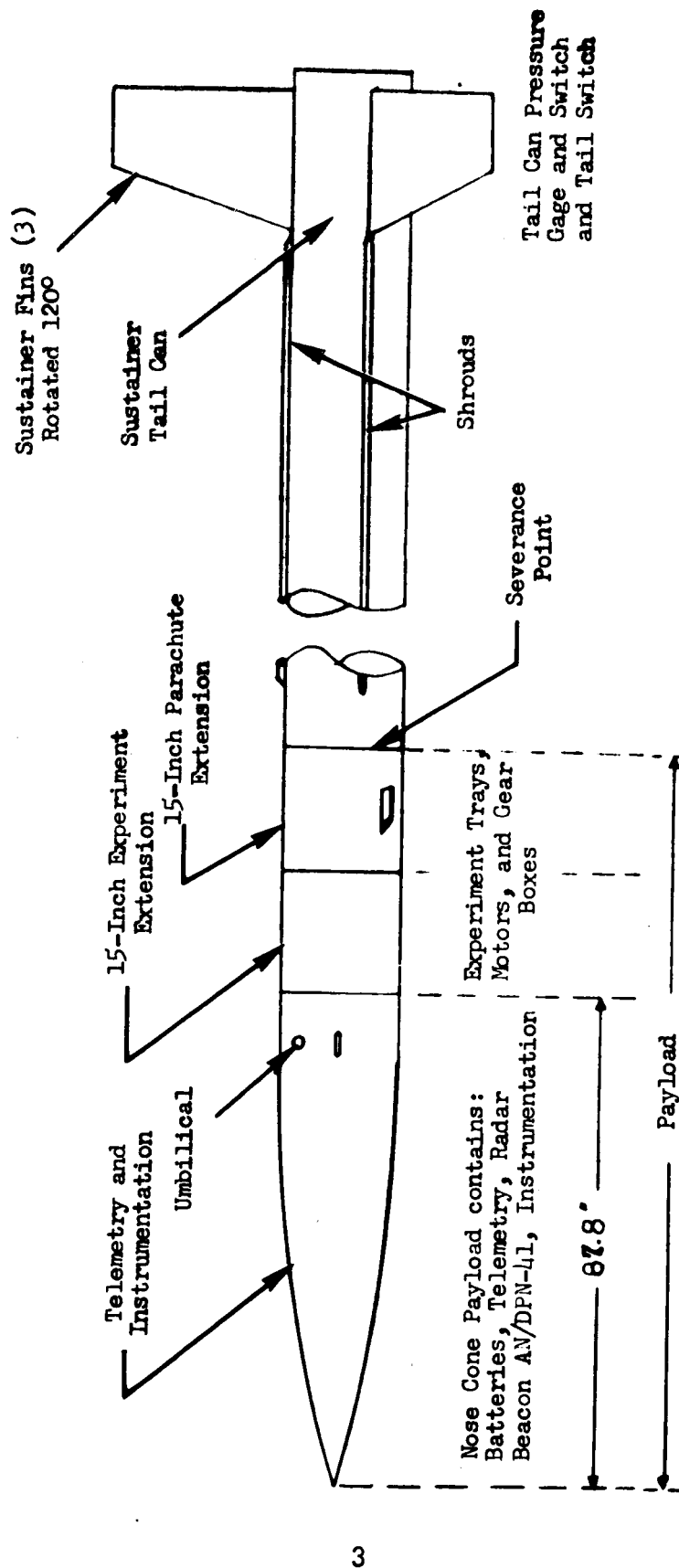


Figure 1. Mechanical Configuration of Flight 4.107 GE

to investigate the feasibility of this technique as a possible alternate for more involved pressure switching devices. This flight also served to evaluate the transducer's reliability under actual flight conditions.

The thrust accelerometer for each flight was located in the main distribution box on the instrumentation rack (see Figure 2). Longitudinal and transverse magnetometers were located on the top deck of the instrumentation rack. On the second deck were the magnetometers' electronics. The third deck consisted of telemetry and instrumentation batteries (Twenty Yardney HR-1 DC Silvercells). On the fourth and fifth decks were located the experiment motor power batteries and the severance batteries, respectively (20 HR-1 and 8 HR-1 DC Silvercel packs, respectively). The sixth deck was empty. Decks 7 and 8 contained the battery pack and power supply for the AN/DPN-41 radar beacon and the radar beacon itself (respectively). The Haydon timer, G-switch, and G-timer were located on the 9th deck. In-flight calibrator, distribution box, and the telemetry transmitter were located on the 10th deck. Protruding out of the 15-inch experiment extension is the upper portion of the experiment, which is shown under the 10th deck of the instrumentation rack. The thrust chamber pressure gage and pressure switch were located in the tail can of the Aerobee sustainer, adjacent to the pressure chamber.

TELEMETRY SYSTEM

A 2-watt, FM/FM transmitter (Vector Model TRPT-2V), modulated by five voltage-controlled, subcarrier oscillators (VCO's), transmitted data from the transducers. Channel switch, occurring at T+56 seconds, allowed the sharing of data on the tray motors with data from the accelerometer, pressure gage, and pressure switch on Flight 4.107 GE only.

The FM/FM telemetry transmitter was modulated on a frequency of 234.0 mcs, with a frequency deviation of ± 125 kcs. VCO parameters were as follows:

<u>FREQUENCY</u>	<u>IRIG CHAN</u>	<u>ALLOCATION</u>
30.0 kcs	15	*P switched at T +56 seconds to monitor experiment's "B" motor
22.0 kcs	14	Accelerometer switched at T +56 seconds to monitor experiment's "C" motor
14.5 kcs	13	**P switch closure time shared with experiment's "A" motor monitor

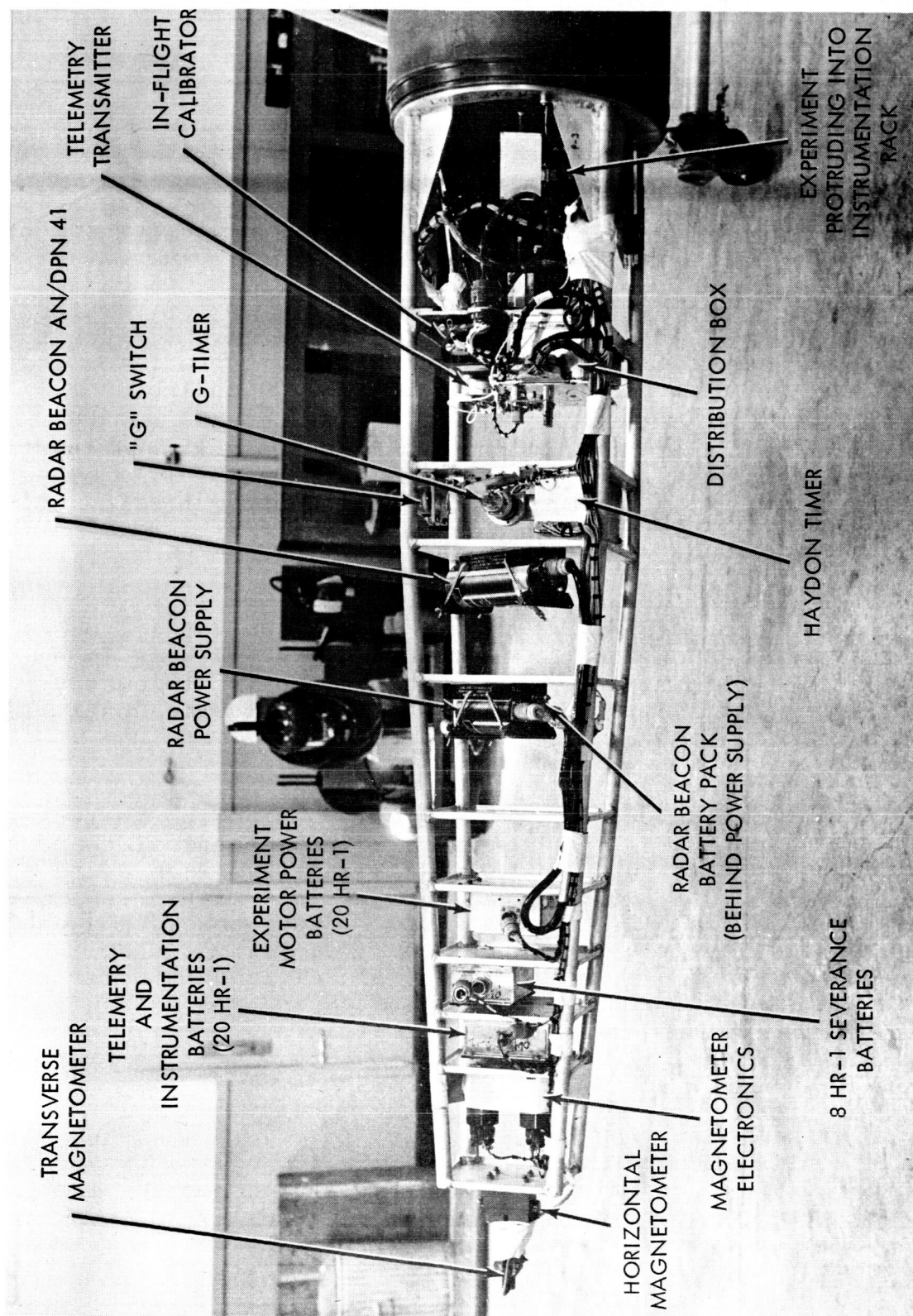


Figure 2. Payload Rack Showing Instrumentation

10.5 kcs	12	Longitudinal magnetometer
7.35 kcs	11	Transverse magnetometer

* P_c gage only used on Flight 4.107 GE.

** P_c switch only used on Flight 4.107 GE.

Each channel deviated in frequency by ± 7.5 kcs. Figure 3 provides the instrumentation and telemetry block diagram for both flights.

An in-flight calibrator provided periodic system verification of data reference points. In operation, see Figure 4, each data channel was sequentially switched from data to a precision staircase voltage generator, calibrating each VCO channel over the range from 0 to +5 volts in 1-volt steps. In-flight accuracy of the calibrator is within 0.1 percent. When calibration of one channel was completed, that channel was switched back to data, and the next channel was calibrated. Calibration of each channel continues until all channels have been calibrated. The calibrator then waits 15 seconds and repeats the cycle.

The transmitter's radio frequency output was radiated via a pair of Quadraloop antennas (New Mexico State University Model No. 2.041), mounted on the parachute extension canister (see Figure 1). The transmitter, as well as the entire telemetry system, was powered by twenty Yardney HR-1 DC Silvercel batteries.

EXPERIMENT

A 15-inch extension, located directly behind the instrumentation rack, contained the necessary electro-mechanical components to extend and retract three nuclei emulsion trays from ports located around the extension (see Figure 5). Contained within the extension are the tray assemblies, housings, motors, gear boxes, and other components which operate the experiment (see Figures 6 and 7). These components, though interrelated, are divided into two groups: the drive and telemetry tray monitor system and the extend/retract control assembly.

Drive and Telemetry Tray Monitor System

This system comprises the tray motors, gear boxes, and motor monitor circuits which drive the trays throughout the Extend and Retract cycles. In addition, this system also comprises those components which switch voltage levels mechanically to check on the success of these cycles. Extent of cycle operation is telemetered to the ground stations. Should the trays not retract fully, indications of this malfunction appear on the ground station telemetry.

Calibrate Period - Occurrence is adjustable between 15 and 90 seconds
 Calibrate Duration - Frequency is adjustable between 0.16 and 1.6 seconds

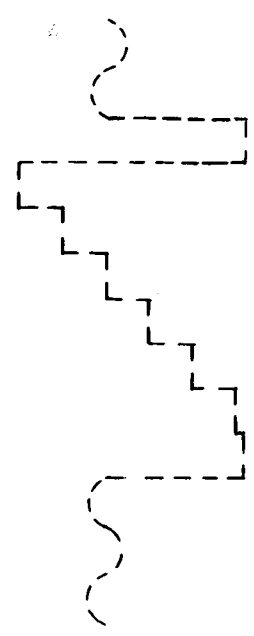
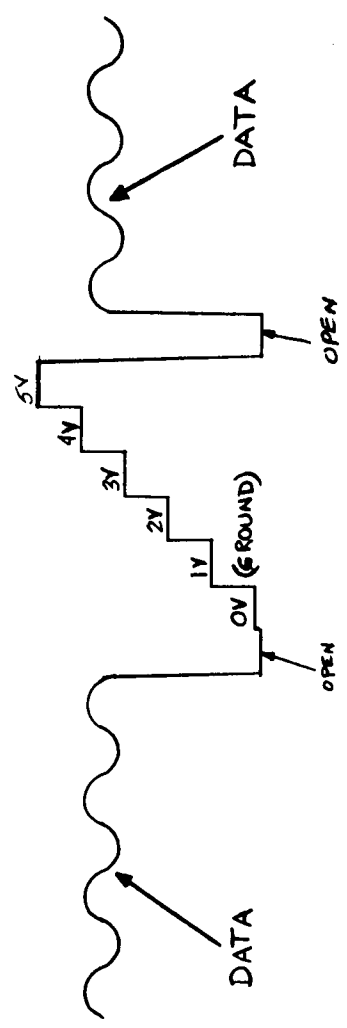
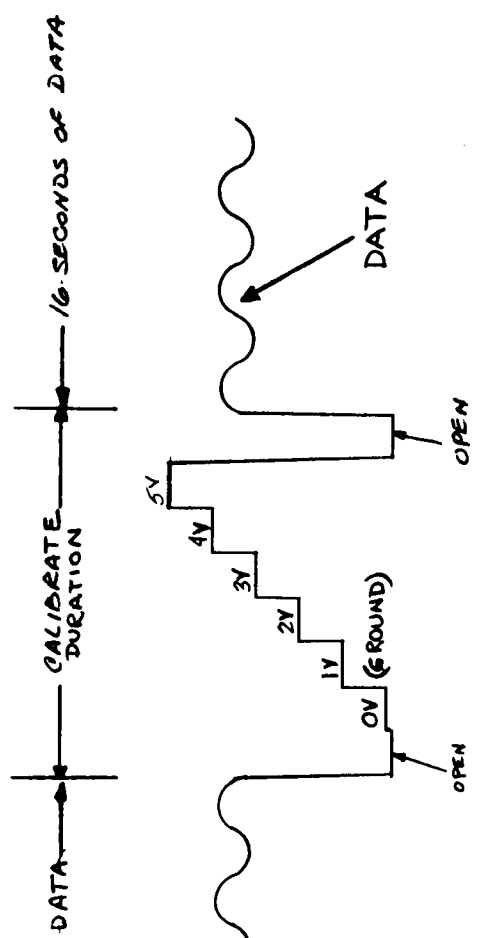
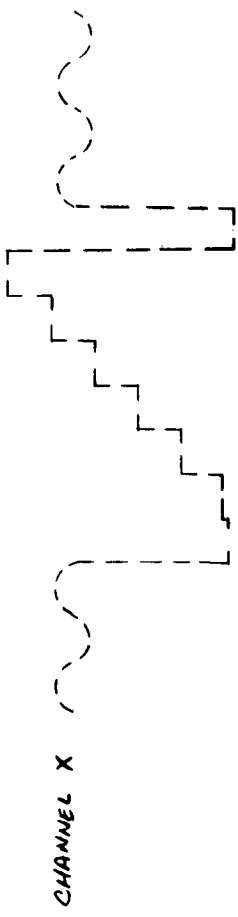


Figure 4. Typical In-Flight Calibrator Voltage Sequence

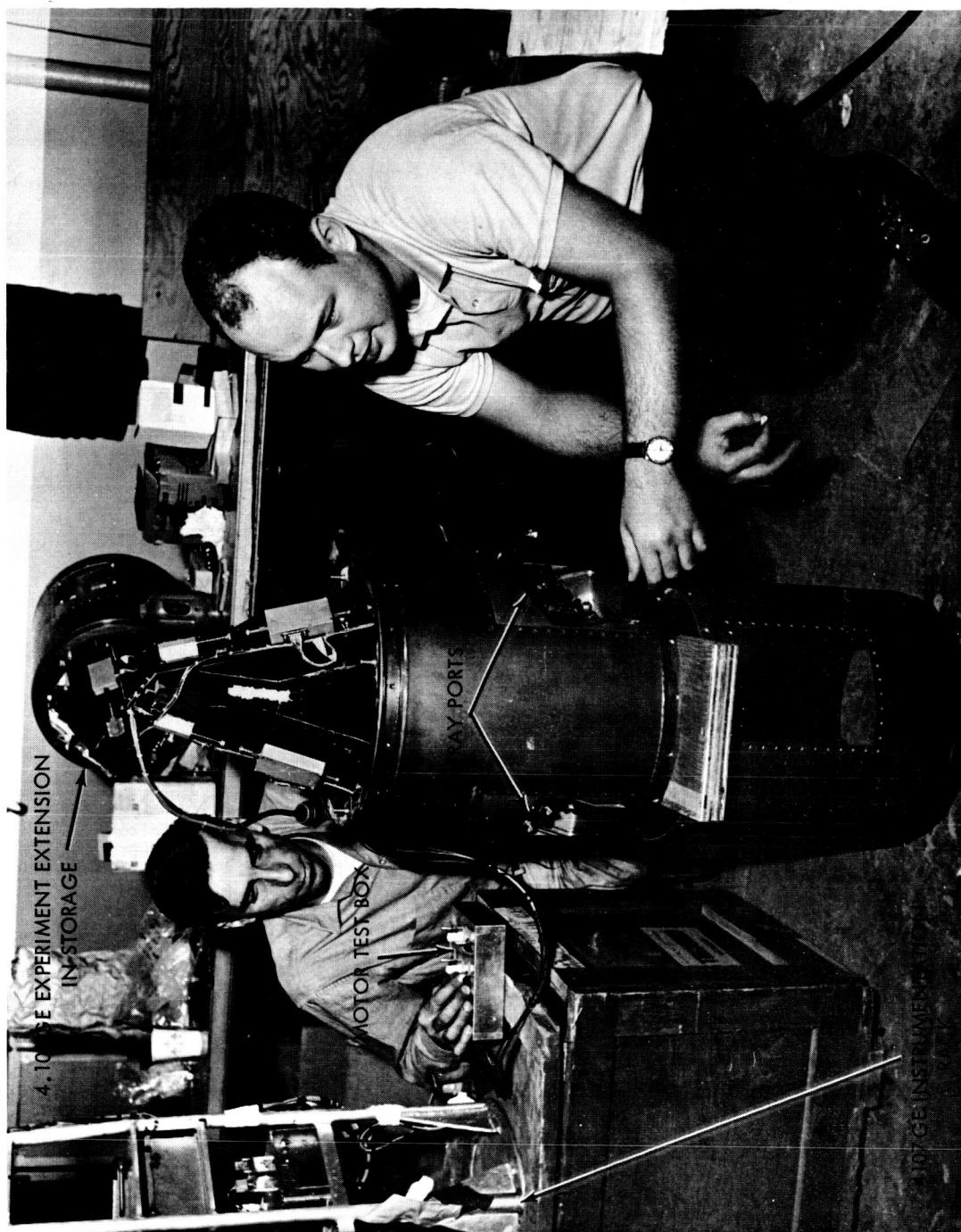


Figure 5. Aerobee Payload 4.107 GE 15-Inch Experiment Extension During Extend/Retract Check at Ft. Churchill

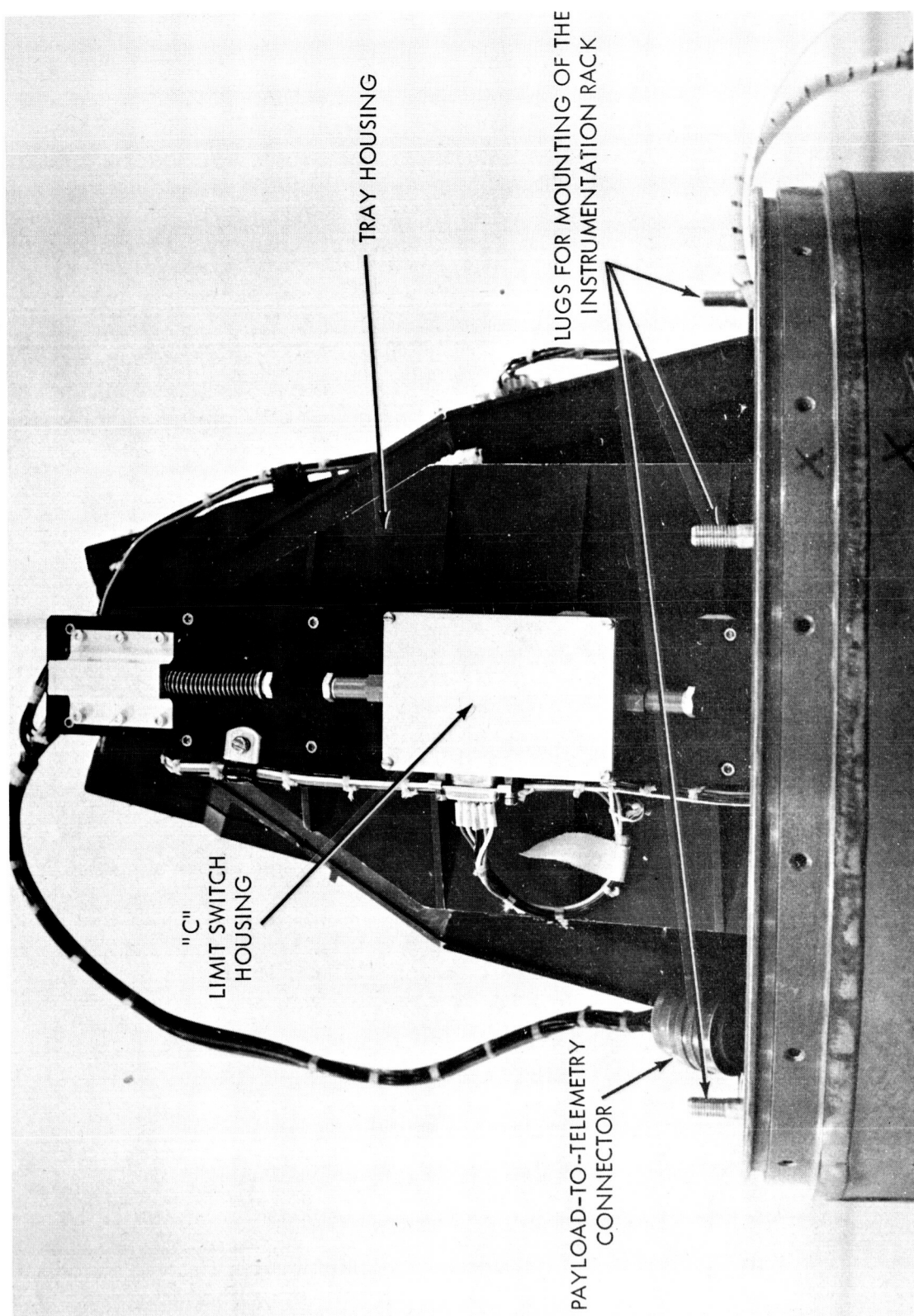


Figure 6. Side View of 15-Inch Experiment Extension

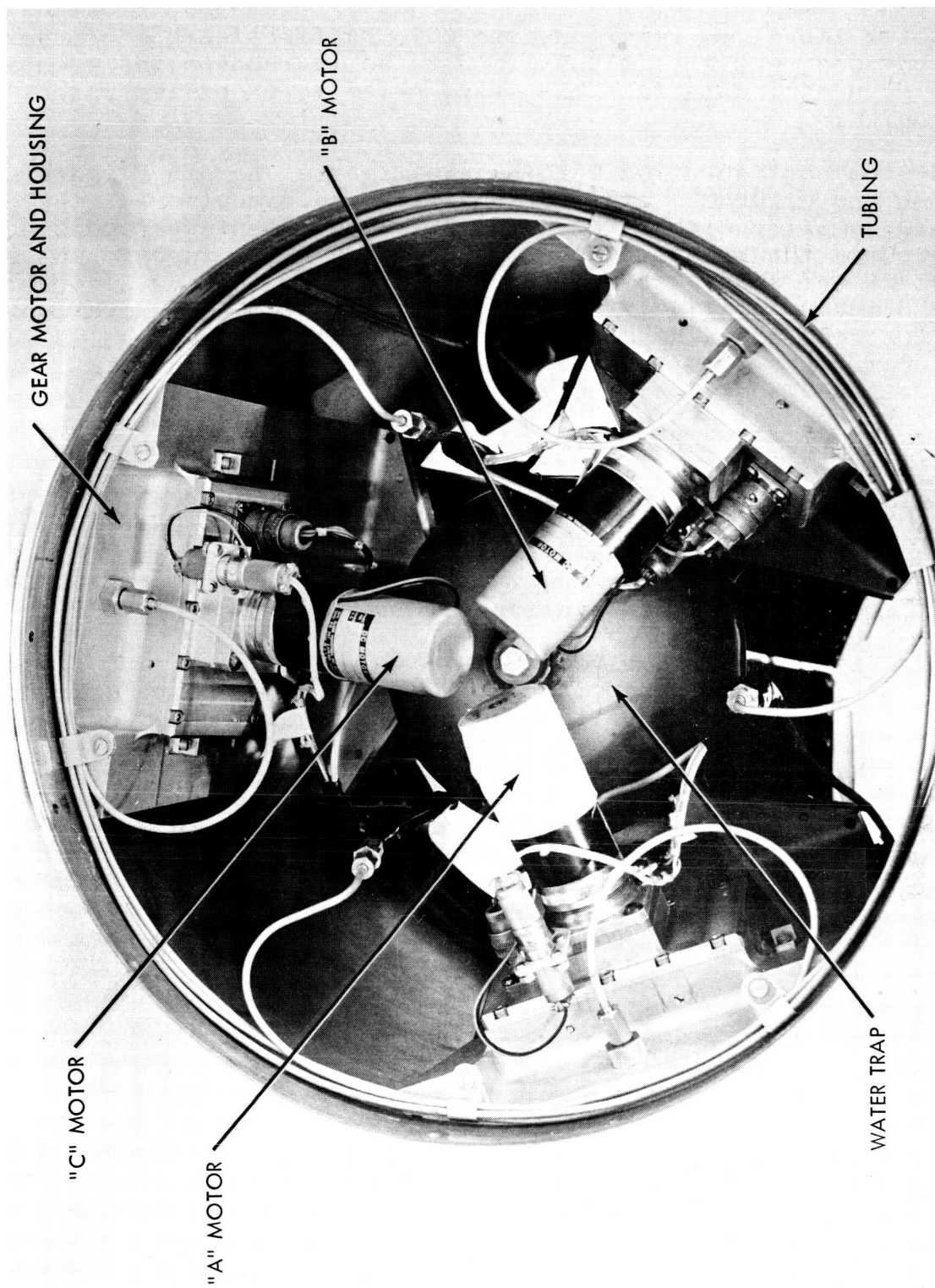


Figure 7. View of 15-Inch Experiment Extension Looking Forward

If a water impact is reported, and this malfunction has occurred, rapid payload recovery is justified so as to recover the greatest amount of useful data from the trays prior to excessive water exposure.

System configuration for the experiments on both Flights 4.107 GE and 4.108 GE were the same with one exception... the "A" motor monitor circuit on 4.107 GE's experiment was modified to include a thrust chamber pressure switch which functioned between lift-off and sustainer burnout (approximately 52 seconds). Figure 8 schematically illustrates this circuit, the cam of which is preset such that the microswitch arm contacts the flat surface of the cam. For the first 63 seconds, with the cam set in the aforementioned position, the microswitch arm makes contact with the "flat" contact of the "A" motor monitor switch, which is tied directly to the 14.5-kcs telemetry input. In this condition, approximately 4.7 volts is continuously applied to the telemetry system for transmission to the ground station recorders. At lift-off the sustainer chamber pressure rises, changing the P_c switch from the "close" contact position to the "open" contact position. This results in shunting the 4.7-volts to 0.9 volts, which is telemetered to the ground station indicating switch operation.

At sustainer burnout, chamber pressure decreases and closes the P_c switch, in turn causing the 0.9-volt level to be shifted to 4.7 volts. This is monitored by instrumentation personnel in the ground station. The 4.7-volt level remains until T +63 seconds, when the Haydon timer causes the motor cam to rotate, extending the emulsion trays. Each complete rotation of the cam indicates that the tray arm has moved approximately 0.2 inch, either in the extend or retract direction. For that portion of each rotation, when the microswitch arm is on the flat surface of the cam, 4.7 volts is telemetered to the ground station recorders. Conversely, when the microswitch arm is on the rounded surface of the cam, the telemetry input arm is grounded to the "round" microswitch contact, telemetering a 0-volt level to the ground station.

Tray motor monitor circuits "B" and "C" on both flights were electrically and mechanically identical. The "A" motor monitor circuits for both flights differed electrically in that Flight 4.107 GE's circuit contained a P_c switch and a 1000-ohm shunt resistor. Voltage level switching, indicating the condition of the motor monitor circuits, were telemetered to recording ground stations. "A" motor monitor circuit switched voltage levels from 4.7 to 0 volts, whereas "B" and "C" motor monitor circuits switched from 1 to 0 volts. Since the P_c switch and resistor were not flown on Flight 4.108 GE, presetting of its cam was unnecessary.

Extend/Retract Control Assembly

The extend/retract control assembly, shown in Figure 9, is mounted adjacent to the tray arms in the tray housings. Trays are

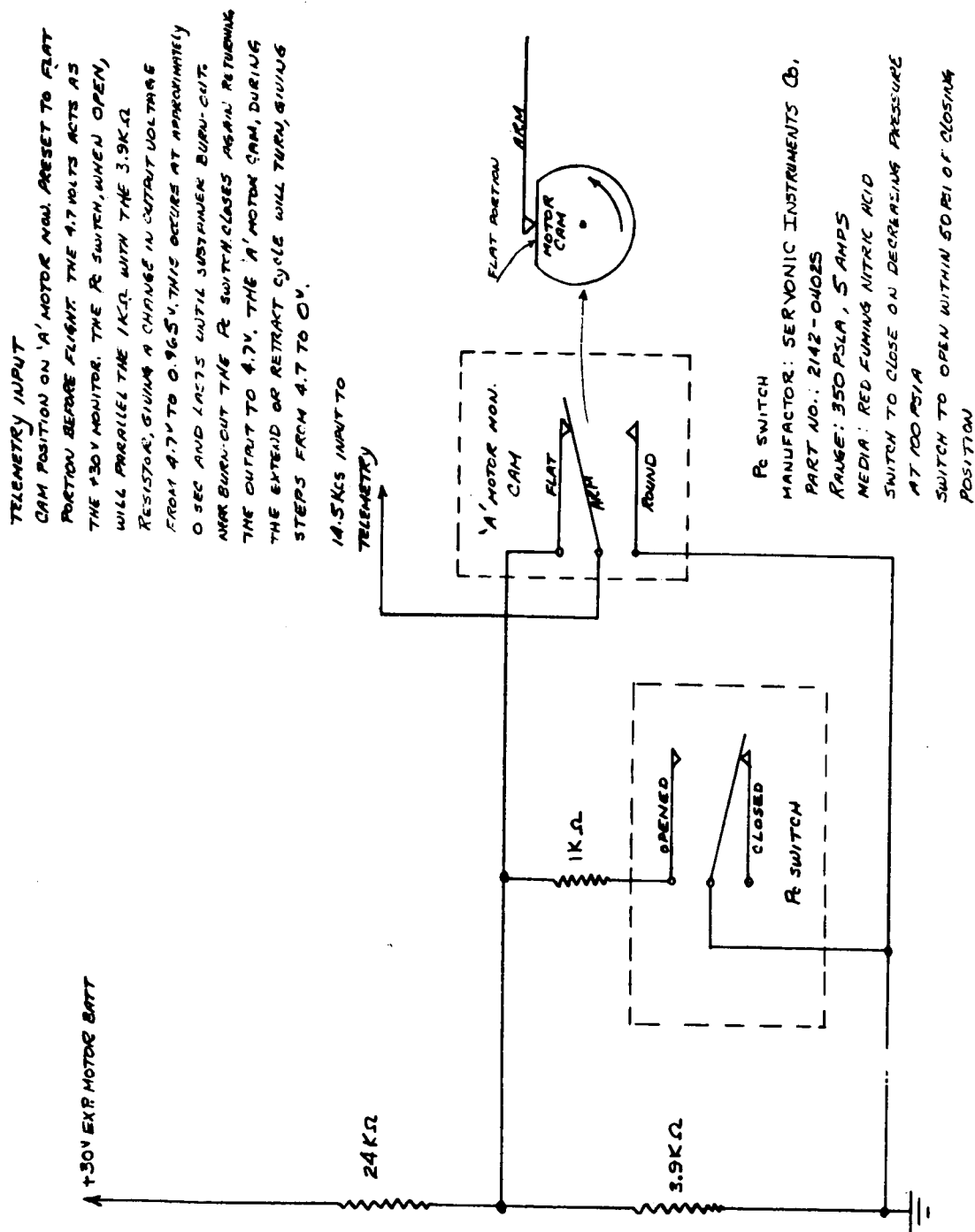


Figure 8. "A" Motor Monitor Channel Modification

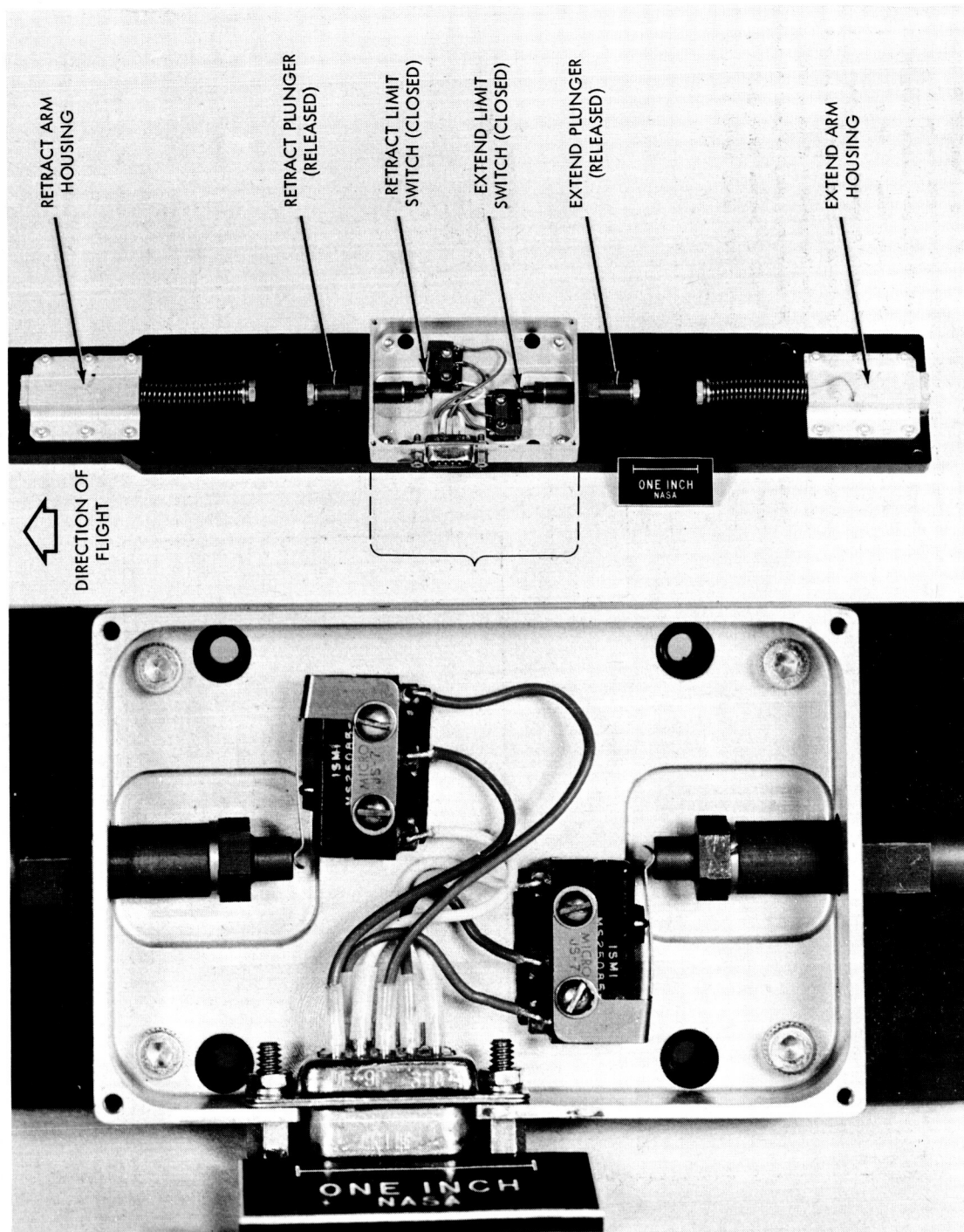


Figure 9. Extend Retract Control Assembly "C" Motor

extended and retracted through the tray ports (shown in Figure 5). (Note that the extend/retract control assembly, shown in Figure 9, is displayed in its actual flight orientation in Figure 6.)

Each tray had its own motor, cam, and extend/retract network. Operation of any one tray was independent of any other tray regarding operation event times, limits, etc.

At ~~T~~+63 seconds, the Haydon timer completed circuitry to start the tray motors (as shown in (1) of Figure 10). At this time the tray motor limit switches are in the fully retracted position since the tray is fully retracted. The retract limit switch is in the open position, since the spring-loaded retract plunger is depressed by the tray. (On the underside of each extend/retract control assembly, an arm is attached to each plunger such that when the tray has traveled its desired distance, the plunger is depressed by the arm.)

To start the tray motors at T +63 seconds, Haydon timer cams 5, 7, and 9 switch from ground potential to +30 volts, applying power to the tray motors for the 12-second extend cycle. The trays begin to extend, thereby releasing the depressed retract plunger, allowing it to move and close the retract limit switch. As shown in Figure 10 (2), this only switches the ground path on the motor and does not interrupt the extend cycle. The tray continues to extend until it pushes the other arm which, in turn, depresses the extend plunger. (This operation occurs after a minimum of 64 revolutions of the motor monitor cam.) With the extend plunger depressed, the extend limit switch is now free and will open, switching off power to its associated tray motor. (Figure 11 shows the assembly in this configuration.) This is a safety precaution to override the Haydon timer by switching off battery voltage to each tray motor when the tray was fully extended, preventing the motor from running and trying to drive the tray further out once the cycle was completed. (NOTE: The same safety precaution is taken following the retract cycle.)

At T +75 seconds, Haydon cams 5, 7, and 9 switch back to a ground potential (see (3) of Figure 10). The trays remain extended until T +414 seconds, at which time Haydon cams 6, 8, and 10 switch, as programmed, to apply 30 volts to the motors, beginning the retract cycle. Note the change in applied polarity across each motor. Now the motor drives the tray gears in the opposite direction from that used during the extend cycle, retracting the trays. Soon after the trays begin moving, the extend plunger is released and the extend limit switch is allowed to close (switching the ground potential path only, as in 2). The tray continues to retract until it depresses the retract arm, causing the retract plunger to depress and allow the retract

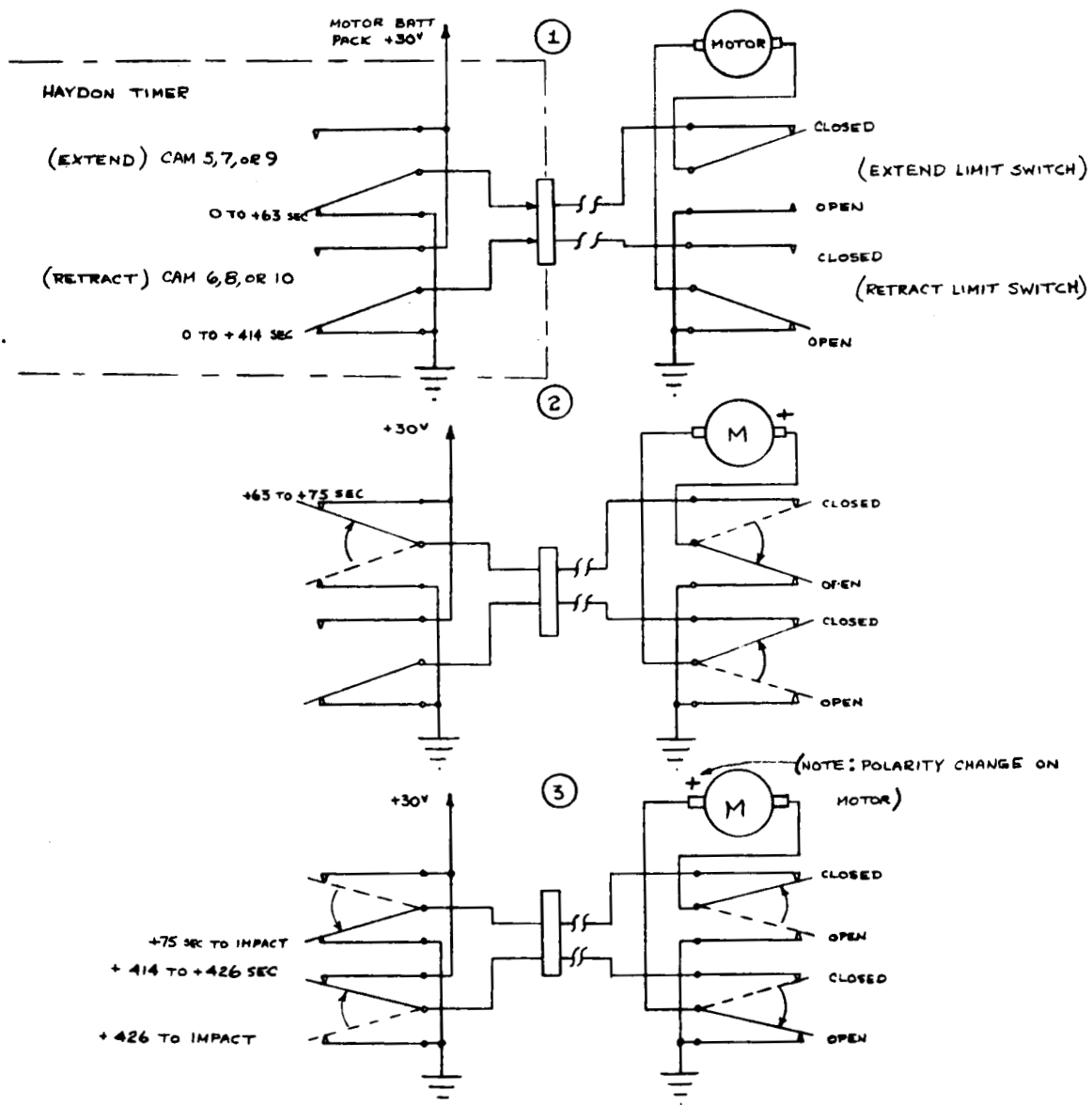


Figure 10. Tray Motor and Cam Operation Schematic Diagram

SWITCH POSITION
WHEN TRAYS ARE
FULLY EXTENDED
(63-75 TO 414
SECONDS)

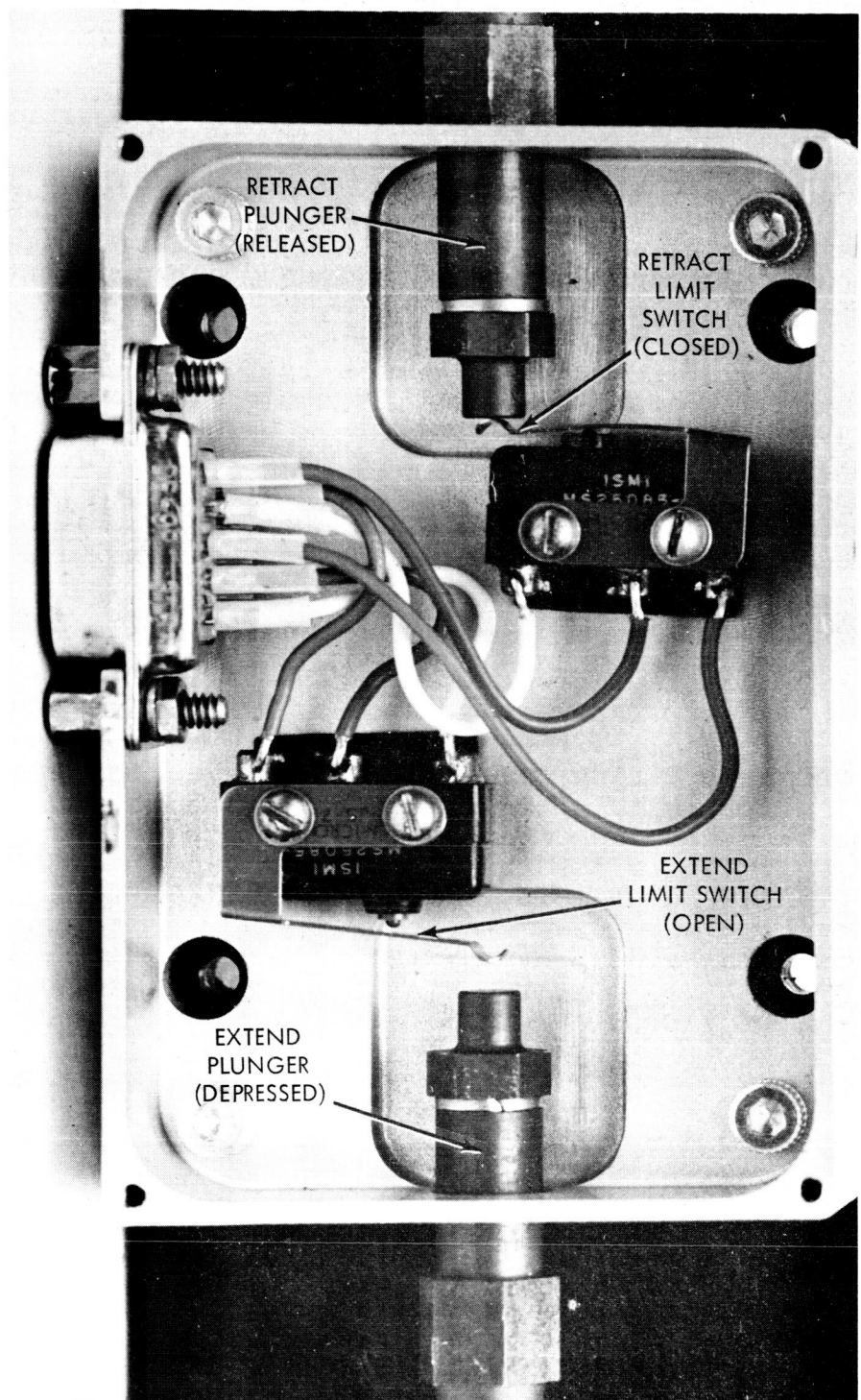


Figure 11. Extend/Retract Limit Switch Housing

limit switch to open. This eliminates power to the tray motors and the trays are retracted fully, as before flight. Haydon timer cams 6, 8, and 10 switch back to ground at the end of 12 seconds.

BEACON SYSTEMS

One pair of radar S-band beacon Quadraloop antennas (New Mexico State University Model No. 6.005) for the AN/DPN-41 radar beacon, were mounted on the nose cone (see Figure 2). The beacon was provided and installed by personnel at the Fort Churchill Range.

A SARAH recovery beacon, with folded-band antenna, was provided and installed in the parachute extension cansiter. Normally, activation of the recovery beacon causes the automatic transmission of special, coded pulses which are immediately identified visually on search craft receivers, guarding a frequency of 243.0 mcs. The SARAH beacon allows positive homing until actual recovery of the payload is completed.

TIMER SEQUENCE

An 11-cam Haydon timer mechanically provided the programmed event times. These event times consisted of tray Extend and Retract commands, first and second severance command, and channel switching. During the flight, the Haydon timer provided for channel switching to time-share experiment and housekeeping data, start and end the extend and retract cycles of the experiment trays, separate the recoverable payload from the sustainer (first severance), and deploy the parachute (second severance). First and second severance are primarily governed by the Haydon timer, which is backed up by the two cams of the G-timer. Originally programmed and changed event times are provided in the following chart:

Event'	4.107GE/4.108GE Original Times (sec)	Flight 4.107 GE Times (sec)	Flight 4.108 GE Times (sec)
Channel Switch	T +56	T +56	T +56
Extend Cycle Start	+63	+63	+63
Extend Cycle End	+75	+75	+103*
Retract Cycle Start	+435	+414*	+414*
Retract Cycle End	+447	+426*	+466*
Severance (Haydon)	+450	+428*	+445*
(G-timer cam 1)	+450	+428*	+445*
(G-timer cam 2)	+451	+430*	+446*

* Reprogrammed

The overall timer sequence was erroneously provided from the original Flight Plan for Aerobee Flight 4.91 GE. Following discussions with Dr. Fichtel, the timer sequence was corrected. Overall timer sequence is shown schematically in Figure 12 and is tabulated in Table 1.

PYROTECHNICS

Severance circuit pyrotechnics (schematically shown in Figure 13), consisted of two severance circuits. First severance separated the payload from the sustainer. Second severance deployed the parachute for the recovery operation. (see NASA/GSFC Report No. 671-64-303). Responsibility for design and installation of the severance circuitry was provided by Sounding Rocket Instrumentation Section.

INTEGRATION

It is intended, during an integration, that any existing incompatibilities are discovered and remedied prior to shipping the payload to the launch site. During an integration, the component parts of a payload (experiment, instrumentation, nose cone, and pyrotechnics) are both mechanically and electrically mated (integrated) and checked out under simulated flight conditions. It is also at this time that the telemetry system is checked against the ground station (Station G is located in the Beltsville building and has FM/FM and PPM capabilities), to ensure that transmitters, VCO's, transducers, experiment, etc. all are properly functioning.

Both payloads, 4.107 GE and 4.108 GE, were successfully integrated at Goddards's Beltsville building. No major problems were encountered and all minor problems were rapidly solved. The payloads were then packed for shipment, via air freight, to Fort Churchill. The flight to Fort Churchill normally takes about five days before the equipment is actually delivered to the launch site.

PRE-LAUNCH PREPARATION

On 14 July, at the Fort Churchill facility, the payload instrumentation rack for Flight 4.107 GE and associated equipment, were unpacked and the payload buildup started. In addition, instrumentation and flight batteries were prepared. A total of 144 Yardney HR-1 DC Silvercel batteries were required; 48 for each payload and 48 other for the various pre-launch checks.

An instrumentation check was conducted to ensure proper operation of flight instrumentation (timers, telemetry, transducers, battery packs, etc.), prior to vehicle mating. This entails

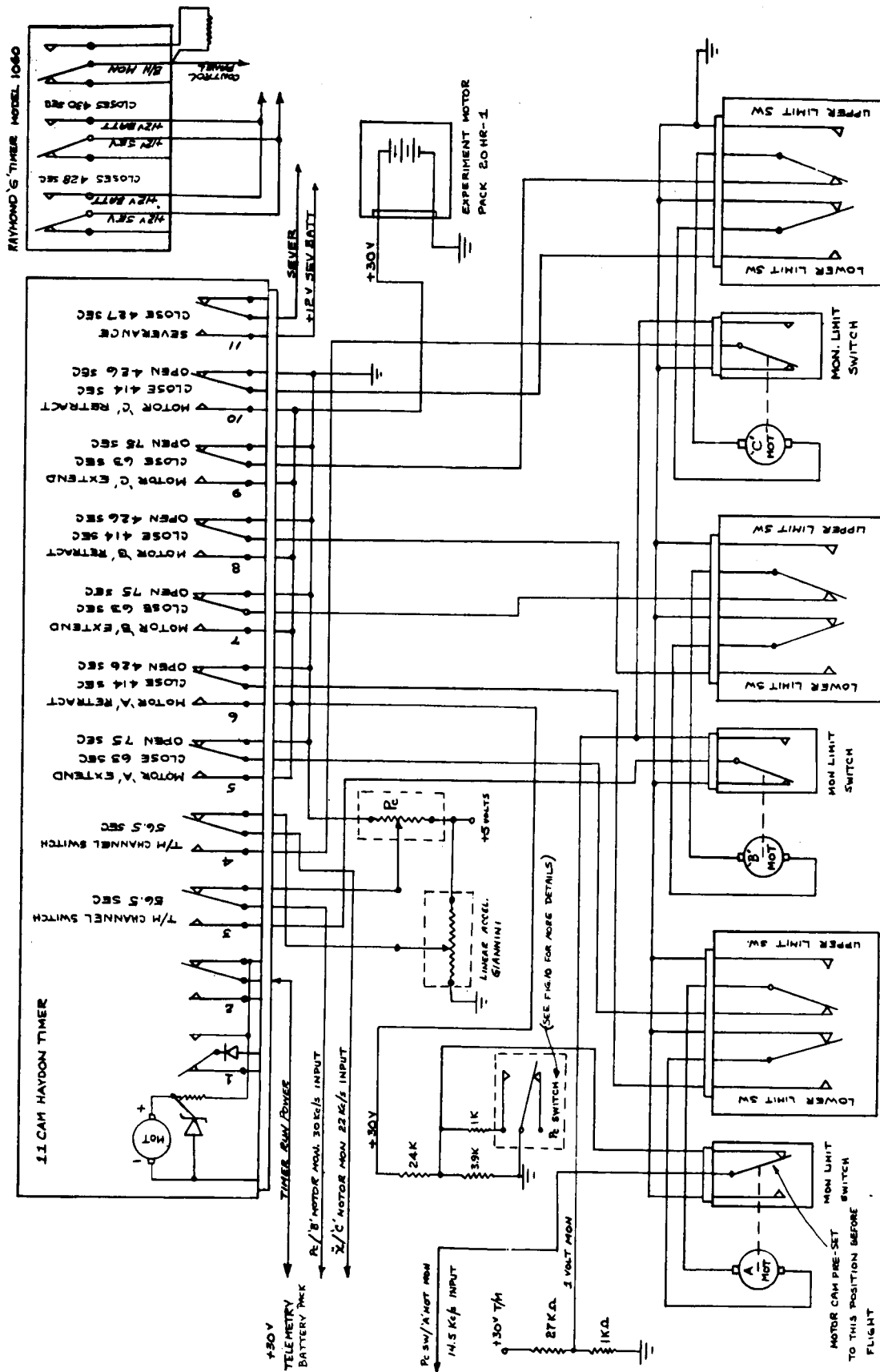


Figure 12. Timing Control System Schematic Diagram

Table 1.

TIMER SEQUENCE FOR FLIGHTS 4.107 GE and 4.108 GE

TIME FROM LIFT-OFF 4.107 GE 4.108 GE	ACTION	VCO VOLTAGE INPUT	IRIG CHANNEL VCO FREQ (KCS)
0	G-timer and Haydon START G-switch trips, 20K FT altitude switches on OPEN position	P Gage output (4.107 GE only; C 4.108, 2.5V voltage divider) Accelerometer output	30 kcs
+56 sec	Haydon timer cams 3 and 4 switch to motor monitor	B motor monitor (OV) C motor monitor (OV) A motor monitor (4.7V)	22 kcs
+63 sec	Haydon timer cams 5, 7, and 9 switch to Extend cycle position for A, B, and C motors respectively	B motor monitor (steps from 1.0V to OV) C motor monitor (steps from 1.0V to OV) A motor monitor (steps from 4.7V to OV)	30 kcs 22 kcs 14.5 kcs
+75 sec	Haydon timer cams 5, 7, and 9 switch back to position held before +63 sec, end- ing Extend cycle	B motor monitor (1.0V or OV) C motor monitor (1.0V or OV) A motor monitor (4.7V or OV)	30 kcs 22 kcs 14.5 kcs
+414 sec	Haydon timer cams 6, 8, and 10 switch to Retract cycle position for A, B, and C motors respectively	B motor monitor (steps from 1.0V to OV) C motor monitor (steps from 1.0V to OV) A motor monitor (steps from 4.7V to OV)	30 kcs 22 kcs 14.5 kcs
+426 sec	Haydon timer cams 6, 8, and 10 switch back to position held before +414 sec, end- ing Retract cycle	B motor monitor (1.0V or OV) C motor monitor (1.0V or OV) A motor monitor (4.7V or OV)	30 kcs 22 kcs 14.5 kcs
+428 sec	Haydon timer cam 11 switches to severance command posi- tion. G-timer cam 1 closes for severance command back-up	B motor monitor (1.0V or OV) C motor monitor (1.0V or OV) A motor monitor (4.7V or OV)	30 kcs 22 kcs 14.5 kcs
+430 sec	G-timer switch cam 2 closes for severance command back-up to +428 sec commands	B motor monitor (1.0V or OV) C motor monitor (1.0V or OV) A motor monitor (4.7V or OV)	30 kcs 22 kcs 14.5 kcs

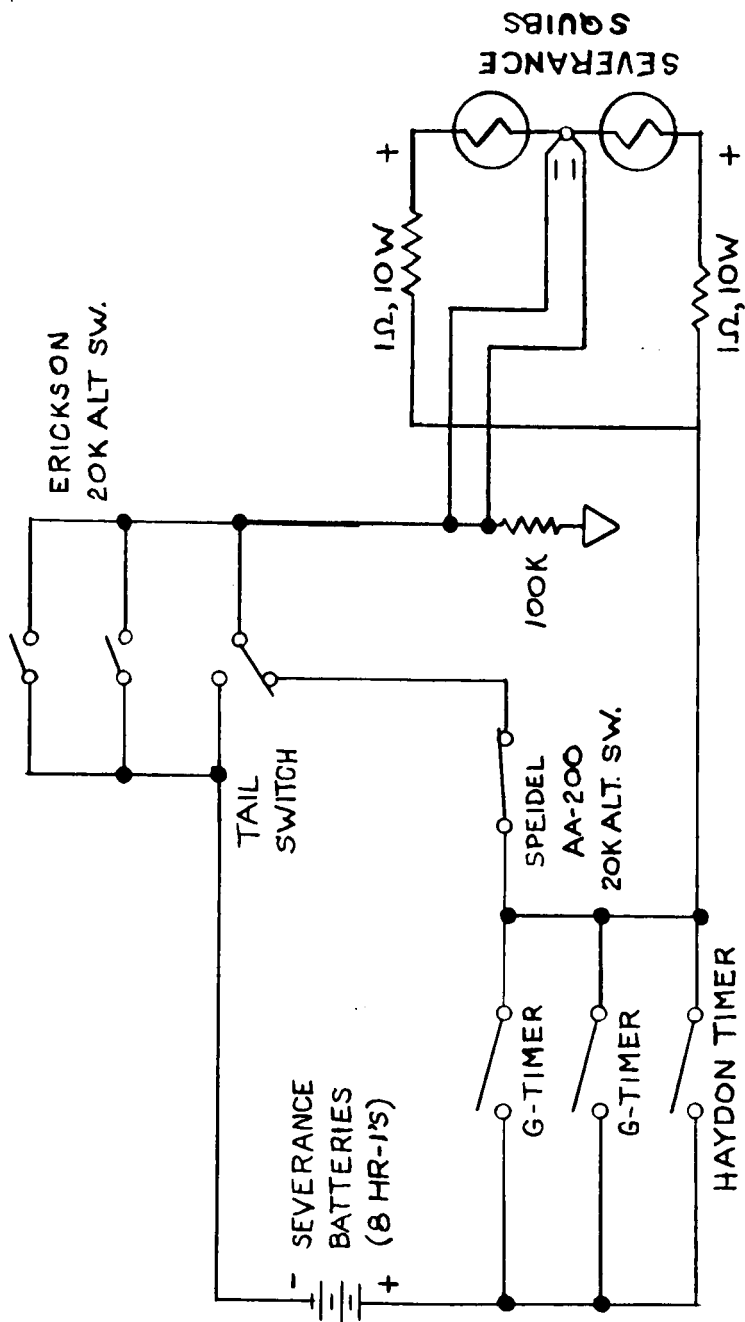


Figure 13. Severance Squib Circuit Schematic Diagram

turning on the transmitter, normally radiating its output into a dummy load. As a result of the instrumentation check, transmitter power was found to be unstable and weak. After replacing the transmitter, the check was reconducted and power was found to be normal.

The following day, 15 July, instrumentation battery packs were readied and installed. Telemetry checks were conducted using the Range ground station and all channels appeared normal. The experiment portion of the payload could not be checked in this test, since it was being prepared for installation. A pressure check was conducted on the pressure switch to ensure its compliance to the calibration switch points. "A" motor monitor channel circuits, on the 14.5 kcs VCO, was modified (see Figure 8), such that the pressure switch information could be obtained on this channel. "A" motor monitor cam position was preset on the flat portion of the cam to obtain a voltage switching level. The pressure switch was mounted, tail wiring and junction box were installed, and the circuit was checked.

Checkout of the SARAH recovery beacon was conducted with a SARAH receiver and found to be operating properly on the 243.0 mcs assigned frequency. It was then mounted in the parachute extension. The parachute actuator box, containing batteries, electronics, and squibs to deploy the parachute, was also checked and its battery pack charged.

Re-calibration of the chamber pressure (P_c) gage was accomplished by applying various pressures to the gage and transmitting the corresponding voltages through telemetry, which were recorded at the ground station. The experiment extension was then mated to the instrumentation rack and a system check was conducted. Programmed times on the Haydon and G-actuated timers were checked for emulsion tray Extend and Retract commands, channel switch, and severance.

The next day, 16 July, following assembly, the payload was taken outside the preparation building and a magnetometer calibration was conducted in accordance with the experimenter's request. Calibration was conducted with the payload radiating into a dummy load and the payload, being physically orientated to various prescribed attitudes, allowed the magnetometer calibration levels to be recorded at the telemetry ground station. After this calibration, the assembled payload was mated to the rocket and a horizontal check was conducted (see Figures 14 and 15 and Table 2). Overall system checks were satisfactory, although no check was made on the AN/DPN-41 radar beacon. Radar beacon checks were not made at this time because the beacon harness had not been installed and the beacon interrogator unit



Figure 14. Flight 4.107 GE Payload Being Mated to the Rocket

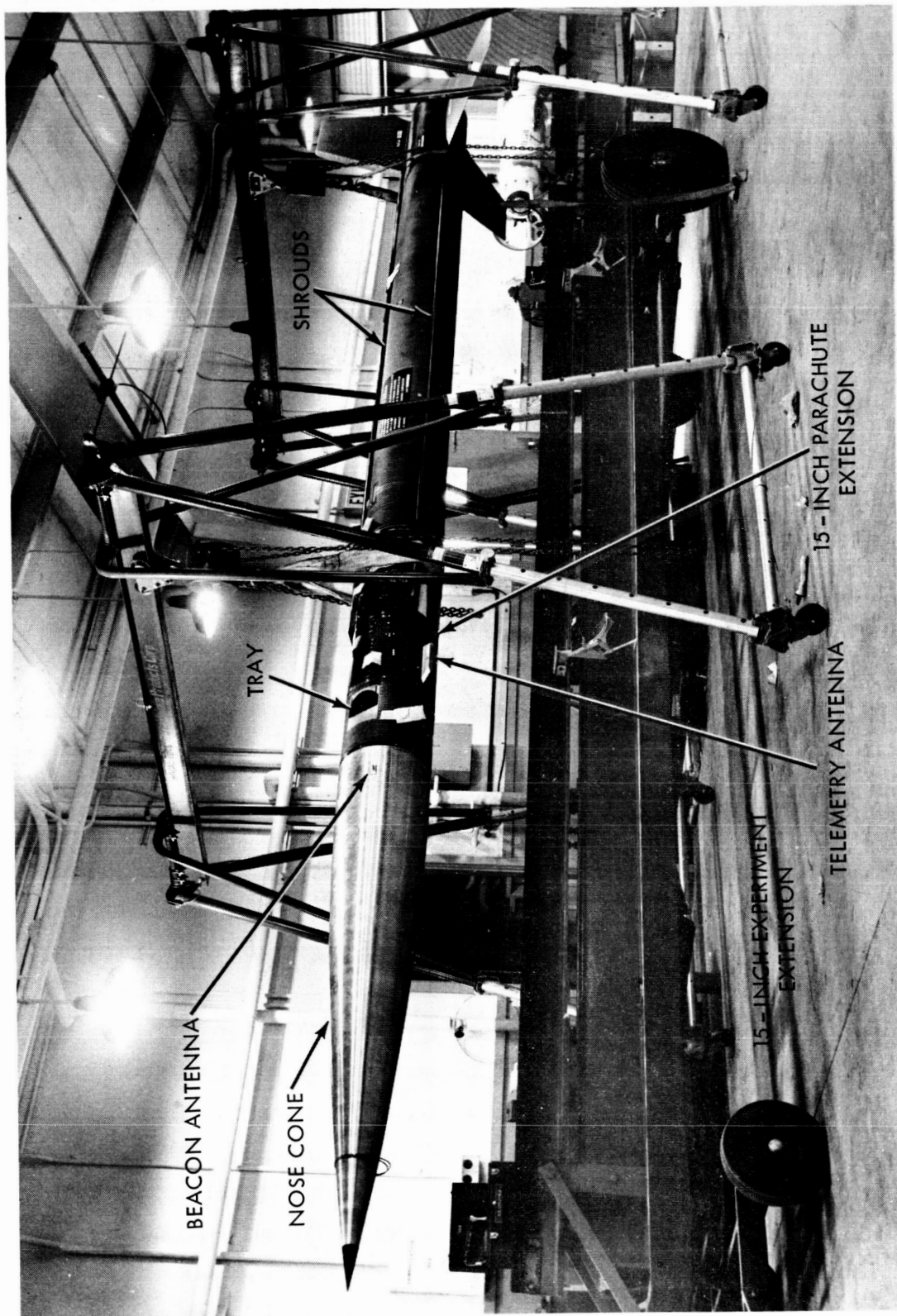


Figure 15. Flight 4.107 GE Assembled for Weight Measurement

Table 2. Horizontal and Vertical Countdown Check

COUNTDOWN (Sec)		FUNCTION
4.107 GE	4.108 GE	
T -3 min	T -3 min	Telemetry and instrumentation on EXTERNAL POWER. (Ground station acknowledges signal.)
T -2 min	T -2 min	Ground station recorders ON SLOW (1.0 ips).
T -1 min	T -1 min	Payload switched to INTERNAL POWER.
0	0	Pullaway Out - Start G-timer.
T +30 sec	T +30 sec	Excite Magnetometers
T +40 sec	T +40 sec	Interrogate radar beacon (vertical only).
T +62 sec	T +62 sec	Recorders switched to FAST SPEED (10.0 ips).
T +63 sec	T +63 sec	Emulsion trays begin Extend cycle (Horizontal only).
T +75 sec	T +103 sec	Emulsion trays complete Extend cycle (Horizontal only). Recorders OFF.
T +412 sec	T +412 sec	Start Recorders FAST SPEED
T +414 sec	T +414 sec	Emulsion trays begin Retract cycle (Horizontal only).
T +426 sec	T +466 sec	Emulsion trays complete Retract cycle (Horizontal only).
T +428 sec	T +445 sec	Severance - Confirm via test box (Horizontal only).
T +480 sec	T +480 sec	Pullaway IN. Switch to EXTERNAL POWER, then OFF. Stop recorders, checks complete.

was not available in time for this check.

As previously mentioned, programmed payload event times were found to be in error, since it was assumed that the payload for this Flight was identical to Flight 4.91 GE. Reprogramming of the Haydon and G-timer necessitated a long and tedious change, since a stop watch was the only applicable timepiece available. Page 13 lists the original times and the reset times. Haydon and G-actuated timers were remounted and horizontal checks were reconducted. System and timer changes checked satisfactorily and the payload was considered acceptable for flight.

On 17 July, a new umbilical had to be made since the one to be used in the tower was found to be approximately one foot too short. Lengthening of the umbilical was accomplished by splicing an extension to the one on hand. This was accomplished and the umbilical was checked through to the blockhouse control panel. Considerable time was involved on the umbilical correction.

The rocket, with the payload mounted, was readied for the tower (see Figure 13). Total length of Flight 4.107 GE was such that the completely assembled Aerobee was longer than the removable tower rail, necessitating removal of the nose cone to allow insertion clearance into the tower.

On Saturday, 18 July, Aerobee 4.107 GE was installed in the tower and the tail switch circuit rechecked. The beacon harness was checked through the junction box by the Range personnel and found to be satisfactory. Instrumentation-check battery packs were replaced with flight battery packs.

The following day, Sunday, 19 July, the nose cone pressure check was conducted. A high rate of leakage was noted and corrective measures had to be taken. Leak detection was lengthy, in that pressure had to be applied, its level monitored over at least a one-hour period, and leak detector fluid applied to the many suspected areas. In addition, the nose cone had to be removed after each pressure check to reach and seal most of the leaks. Leaks were found in the experiment section, around the payload umbilical mount, and the O-ring on the 15-inch experiment extension.

The telemetry was checked, using the Range ground station, thereby also double-checking the umbilical hook-up to the blockhouse. Some noise was observed on all data channels, but since the telemetry was satisfactory during the horizontal checks, the noise was attributed to RF reflection from the enclosed metal tower. Pan American ground station personnel stated that noise indications were often encountered while radiating in the tower, but the signal "cleans up" after the rocket leaves the tower.

"Cheater" antennas were used for re-radiating the rocket RF telemetry signal as well as the radar beacon. (In order to check flight antennas within the all-metal Aerobee launch building, "cheater" antennas had to be placed within the launch building.) A check was made, with the telemetry connected to a dummy load and, as expected, the noise level was reduced to an acceptable level.

On Monday, 20 July, the telemetry was rechecked and the "peon" calibrator was found to be malfunctioning. The "peon" was replaced but, when the telemetry was energized again, no modulation was present on the 234.0 mcs carrier. Investigation revealed the absence of the required +6 volts from the VCO's regulator. The regulator was replaced and the problem was resolved. However, inspection of the in-flight calibrator traces revealed more malfunctions. To alleviate this problem, the 4-channel "master" calibrator was replaced and calibrations were again normal.

The following day, 21 July, range radar beacon personnel, under the supervision of Mr. T. Rhae, informed J. W. Cameron of beacon battery problems. Radar beacon AN/DPN-41 had evidenced a power failure earlier in the month on another flight, and a check on the entire supply of Yardney HR-5 Silvercel batteries was conducted. All batteries were load-checked and found to be below rated capacity. The pack of HR-5's was removed from the payload and a pack of HR-10's substituted. A new battery pack container had to be fabricated, but was accomplished quickly and with no serious problems.

The payload was readied for flight and a vertical check was satisfactorily conducted (see Table 2). Cycling of the emulsion trays could not be conducted during this check because of mechanical interference due to the tower rails; consequently, the Haydon times could not be rechecked.

On Wednesday, 22 July, weather looked bad for a morning launch. However, a Minnesota Cosmic Ray Nuclear Emulsion balloon was launched early in the morning, but winds were high and the sky was overcast. It appeared as though the launching of Flight 4.107 GE would be cancelled during the balloon flight; however, the countdown was started in hopes that the weather would clear by launch time. The T -3 hour check was satisfactory, but during the T -1 hour check, the telemetry signal was not normal. No modulation was present on the carrier signal and, apparently, the +6-volt regulator had failed. Telemetry instrumentation was cycled ON and OFF several times, but the system would not respond. The count was held at T -1 hour and the nose cone was removed from the vehicle. Checking the +6-volt regulator monitor point revealed that no voltage was present. The regulator was removed and the

connector was checked. Connector checks proved satisfactory and a new regulator was inserted. Normal voltage (+6V) was present and, to confirm normal telemetry operation, the complete telemetry system was energized from the blockhouse. Ground station personnel reported good signal via the intercom, but when the regulator "tie-down" screw was tightened, modulation was intermittent. A +6-volt regulator, one that indicated malfunction on 20 July, was inserted, and the same behavior was noted.

Inspection of the VCO bracket was undertaken, but nothing obvious was detected. Flight 4.108 GE's VCO bracket was removed from its payload and installed in Flight 4.107 GE. Upon installation, the telemetry checked satisfactorily with the tie-down screw, either loose or tightened. The nose cone was remounted and the system pressurized, but the launch had been cancelled due to high winds. Flights 4.107 GE's VCO bracket was checked and the problem was found to be an intermittent voltage breakdown between the regulator's +28-volt input pin and the VCO bracket ground when the regulator was under actual load conditions. This condition was easily corrected.

The following day, 23 July, resumption of the countdown was commenced and all pre-launch checks indicated satisfactory conditions. Datarite quick-look telemetry records were set up on one ground station recorder, enabling an in-flight monitor to check on the success of Extend and Retract functions, and one permanent, real-time telemetry record for the same information. Flight 4.107 GE was launched at 1843:07.600Z (see Figure 16), and telemetry looked good until splash. Some dropouts were noted late in flight, but sufficient data was obtained. Datarite records were quickly checked and the retract monitors indicated that only one tray had fully closed; the other two trays, designated B and C, indicated partial retraction. With this information available, and since the recovery craft had radioed that the payload had impacted in the water, the recovery crew was requested to hasten the retrieval. Payload recovery from the water at Fort Churchill was rather difficult, but was finally accomplished and the payload was returned to the blockhouse by helicopter.

As indicated by telemetry, 2 of the 3 emulsion trays had not retracted fully. B and C trays were still extended approximately 1/5 their length and, consequently, had suffered head damage. Some water damage may have resulted, but the full extent of damage was not known at that time.

Tray A was fully retracted, so at least 1/3 of the total desired emulsion data was obtained. All trays were successfully extended, and on time, but the channel switch occurred early

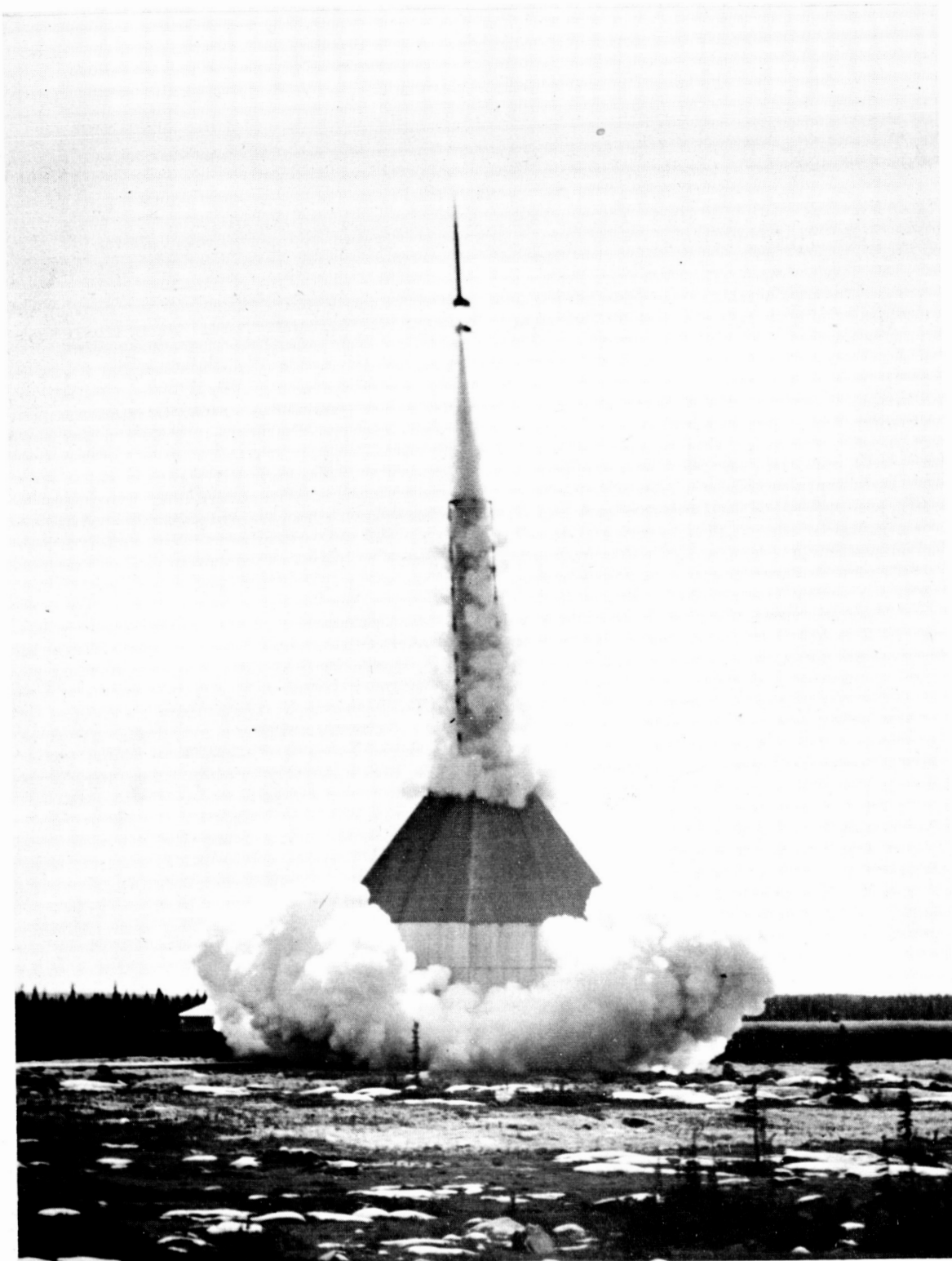


Figure 16. Flight 4.107GE Lift-off

(at +53 seconds) instead of the programmed +56 seconds. The recovered payload was set up and an attempt was made to determine the retract failure via postflight checks. Records were closely examined and three distinct voltage switching indications were noted on the three monitor channels. One indication was the "A" motor voltage cut-off, occurring after the "A" tray was fully retracted, as expected. The other two switch "spikes" indicated a premature voltage cut-off on tray motors B and C.

Haydon timer cycle, set for a full 12 sec (from 414 to 426 sec), had not yet completed its cycle, when spikes were observed and no motor binding was indicated according to the monitor steps. Three voltage spikes were noted at the start and end of the Extend, and also the Retract, cycles, but it was important to note that the spikes occurred at different times to those programmed on the Haydon timer. Inspection of the recovered payload was undertaken and no noticeable mechanical defects were detected.

Signs of electrolyte leakage were noted on the emulsion tray battery pack, but pack was found to be normal under a postflight load check (1 amp for 1 minute). Telemetry batteries had also undergone electrolyte leakage and were severely damaged. The Haydon timer was recycled and the complete timing sequence was checked through the recovered payload. All times were as they had been originally set and the three trays extended and retracted properly. The timing sequence was repeated three times and the recovered tray motor battery pack was used during these checks to extend and retract the trays. "Upper" and "lower" limit switches prevented the tray motor from running after completion of the Extend or Retract cycle. These limit switches are independent of the cutoff switch times from the Haydon timer. During these checks, the payload was physically shaken to check for failure due to vibration, but no failure was found.

Back-up Flight 4.108 GE was readied while investigation on Flight 4.107 GE's payload continued. Results of investigation led only to the opinion that the Haydon timer had somehow skipped time when subjected to flight levels of vibration and acceleration. Early channel switch is one indication that backs up this explanation. However, this timer has been previously flight-qualified for Aerobee environment. No absolute proof of the cause of failure could be found; however, the symptoms were relayed, via telephone, to GSFC and advice was asked pertaining to the launching of back-up Flight 4.108 GE. Permission to proceed with the launching of the back-up flight was obtained and preparations for launch continued. During the flight of Aerobee 4.107 GE, the SARAH beacon was detected on a frequency of 238.0 mcs instead of the normal 243.0 mcs. Fortunately, one of the recovery aircraft was equipped with a tuneable receiver and recognized the 238.0 mcs transmission as that of the SARAH beacon, pinpointing the location of the payload. No explanation was available at that time for the frequency shift.

On Friday, 24 July, the VCO bracket, flown on Flight 4.107 GE, was reinstalled on Flight 4.108 GE's payload. Haydon timer Extend period was changed from 12 seconds to 52 seconds, allowing 3 to 4 times as much time duration to complete the Extend/Retract cycle. This was an added precaution to ensure that adequate time was available for successful tray operation. In addition, severance time was delayed from +428 seconds (on Flight 4.107 GE) to +445 seconds (on Flight 4.108 GE), further ensuring complete retraction of the trays before severance (see page 21 for a complete listing of times).

Haydon and G-actuated timers were programmed for new times and the batteries for the instrumentation check were installed.

Radar beacon AN/DPN-41 and an HR-5 beacon battery pack were installed. Suspected trouble with the HR-5 batteries was non-existent and later was traced to the Range's battery charger. A check was conducted on the instrumentation and it was found to be working satisfactorily. A magnetometer calibration was conducted, tail wiring and box installed, and the SARAH beacon double-checked by Range personnel to pinpoint the transmitted frequency at 243.0 mcs.

A thrust chamber pressure gage or a measure switch was not used on Flight 4.108 GE, as too much time would be required to mount it. A fixed voltage divider was used in lieu of the P^c gage to provide 2.5 volts output on the 30.0 kcs VCO until channel switch. The payload was assembled and mated to the rocket in a horizontal position. A complete horizontal check was then conducted (see Table 2), utilizing the Range telemetry ground station. All programmed times were in agreement and telemetry signal was good.

Flight 4.108 GE was weighed, c.g. obtained, and then installed in the tower. Vertical checks were conducted (see Table 2) and telemetry, as well as the AN/DPN-41 beacon, were checked satisfactorily. Flight battery packs were installed, the nose cone was mounted, and pressure checks were satisfactorily conducted.

On Saturday, 25 July, pre-launch telemetry checks and beacon interrogations were conducted with no apparent problems. Flight 4.108 GE was launched (see Figure 17) at 1735:05.48Z.

Utilizing Datarite quick-look telemetry records as before, the tray's Extend and Retract cycles were confirmed as successful, even before impact.

The payload made a land impact and was relatively easy to recover (see Figures 18 and 19). Radar beacon AN/DPN-41 worked

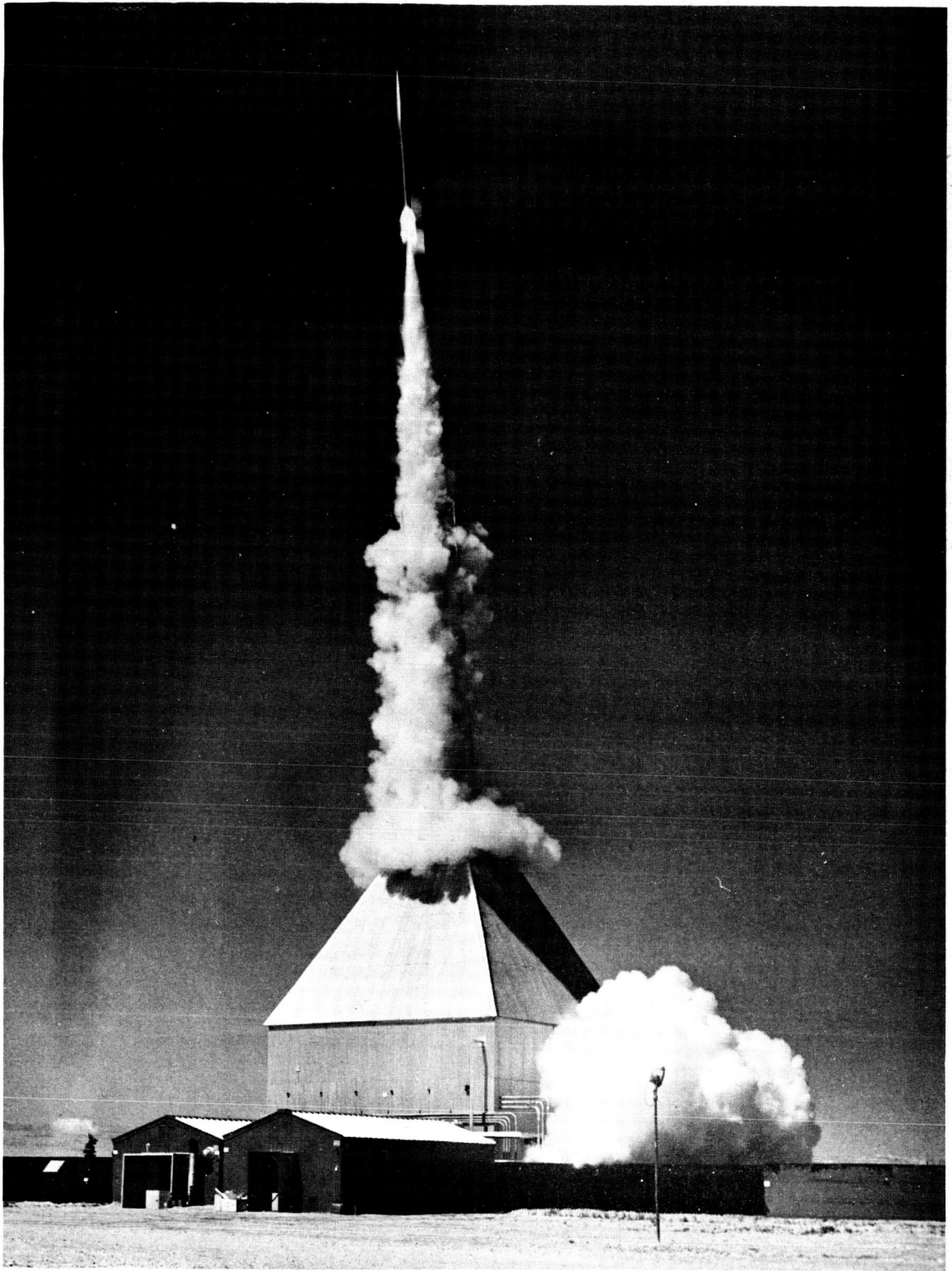


Figure 17. Flight 4.108 GE Lift-off



Figure 18. Recovery of Flight 4. 108 GE's Payload



Figure 19. End of the Recovery Operation

satisfactorily, but the same frequency shift as previously noted, was observed again on the SARAH beacon, as the frequency shifted from 243.0 mcs to 238.0 mcs. This was investigated and antenna deployment interference was discovered. The folded antenna extended fully, but rubbed against the metal parachute pack bumper bracket, causing a 4.0 mcs frequency shift. An additional 1.0 mcs frequency shift was noted when the beacon was removed from the metal parachute container, at which time it was checked and found to be on its correct frequency, 243.0 mcs. As before, on Flight 4.107 GE, the recovery aircraft had a tuneable receiver and the 238.0 mcs was recognized as the location signal of the Flight 4.108 GE payload. The three experiment trays were found fully retracted, as expected, telemetry having already confirmed this condition. Both the telemetry and tray motor battery packs underwent electrolyte leakage, as noted on Flight 4.107 GE, but the instrumentation was apparently in good condition. The flight was considered successful and preparation for shipping equipment back to GSFC was the next order of business.

On the 26th and 27th of July, all support equipment and spare parts were prepared for shipment to GSFC. J. Ducosin then left for GSFC. J. W. Cameron remained on support assignment to Spaerobee Flight 6.10 GA (with personnel from the University of Michigan), which was launched on 28 July.

FIRING DATA

Flight 4.107 GE was launched from Fort Churchill, Canada on 23 July 1964 at 1843:07.600Z. Telemetry was recorded for 1113 seconds with less than one percent telemetry dropout.

Flight 4.108 GE was launched on 25 July 1964 at 1735:05.48Z. Telemetry was recorded for 1320 seconds also with less than one percent telemetry dropout.

Supporting telemetry ground stations (Fort Churchill and Twin Lakes, Canada) sent magnetic tape records to R. W. Conrad, Sounding Rocket Instrumentation Section, GSFC's Beltsville building.

CONCLUSION

All three trays containing the experimental emulsions on Flight 4.107 GE extended properly; two, however, did not retract completely. These two suffered heat damage on approximately 1/5 their length and did not index, as well as becoming wet when the payload impacted in the water. Estimates based on a quick look record showed that 100 percent data were obtained on that emulsion which retracted properly, and 60 percent data of lesser value on the two trays which did not retract fully.

Following a land recovery of Flight 4.108 GE's payload, examination of the emulsion trays indicated that all retracted properly and that very good data can be expected. Telemetry records indicated that the emulsion trays on this flight fully extended and fully retracted in the correct time.

Telemetry and instrumentation provided by Sounding Rocket Instrumentation Section functioned normally except as previously noted, and good acceleration, aspect, and pressure data, from both flights, are expected, as applicable.

Event times for Flight 4.107 GE, originally provided, were those originating from Flight 4.91 GE, since weight and configuration appeared to be the same. In the course of pre-launch checks, the project scientist determined that the programmed times were incorrect. The required timer changes were accomplished in the field using a stop watch for basic timer reference. This was a long, tedious procedure, since no Haydon Timer Test Console was transported to the launch facility.

Early channel switch on Flight 4.107 GE prevented full data coverage on P_c gage and accelerometer. However, they both appeared to function normally. The accelerometer, flown on Flight 4.108 GE, also functioned normally, as did the magnetometers on both flights.

APPENDIX A

Appendix A contains calibration curves derived from calibration data, for Giannini accelerometers and pressure gage. Schonstedt magnetometer calibration data and associated curves are also included.

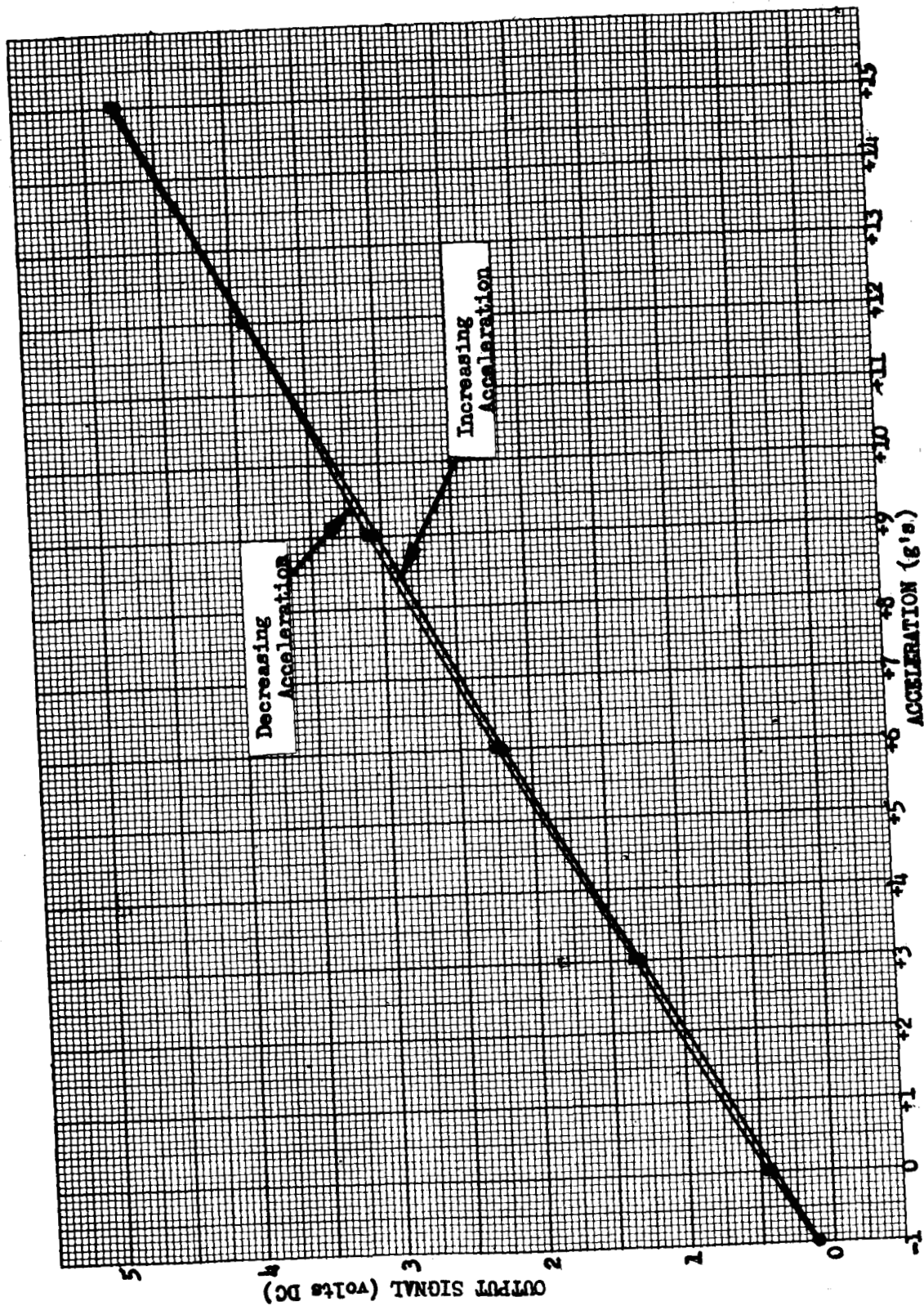


Figure A-1. Flight 4.107 GE Giannini Accelerometer (S/N 6645)

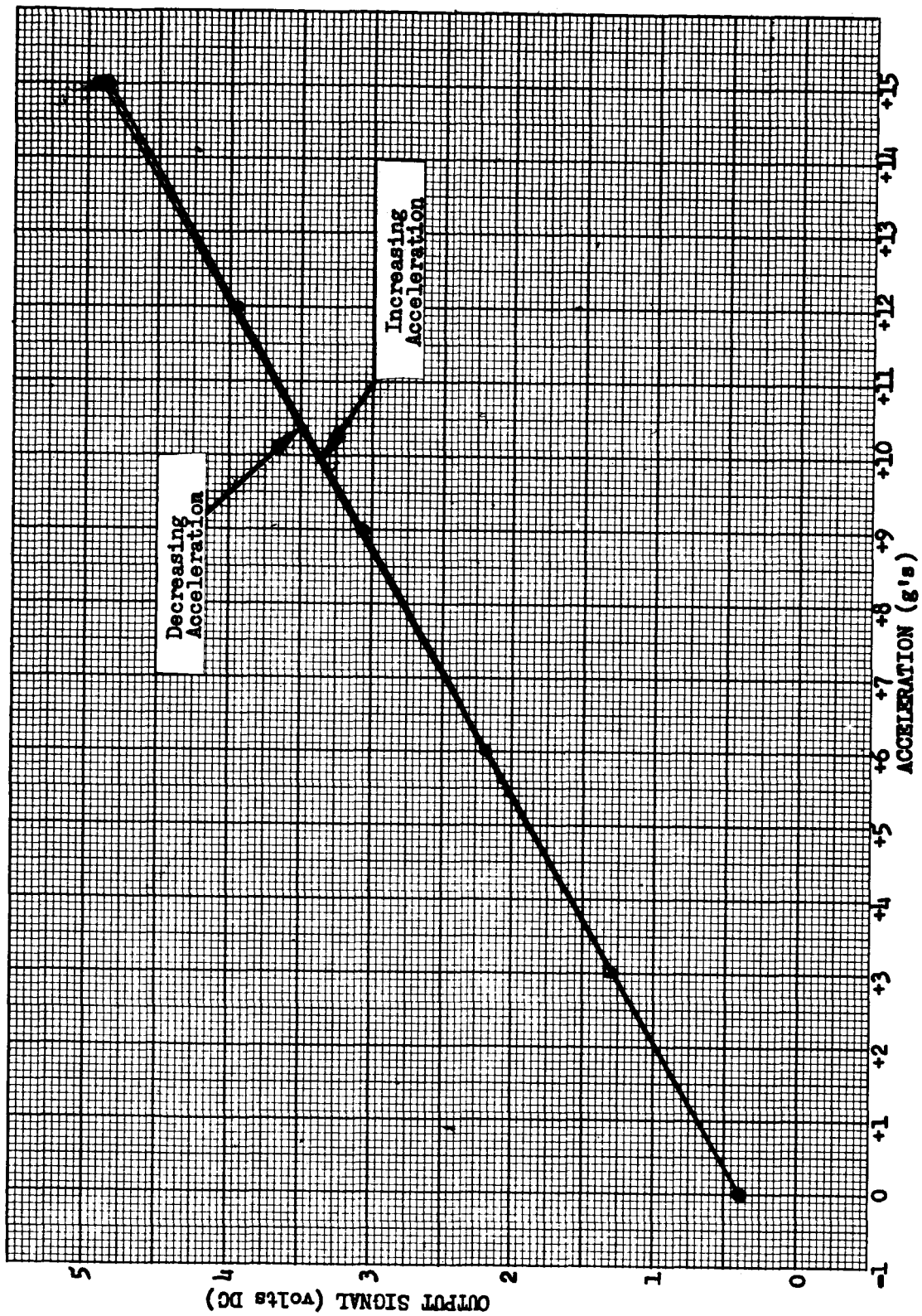


Figure A-2. Flight 4.108 GE Giannini Accelerometer (S/N 380-30)

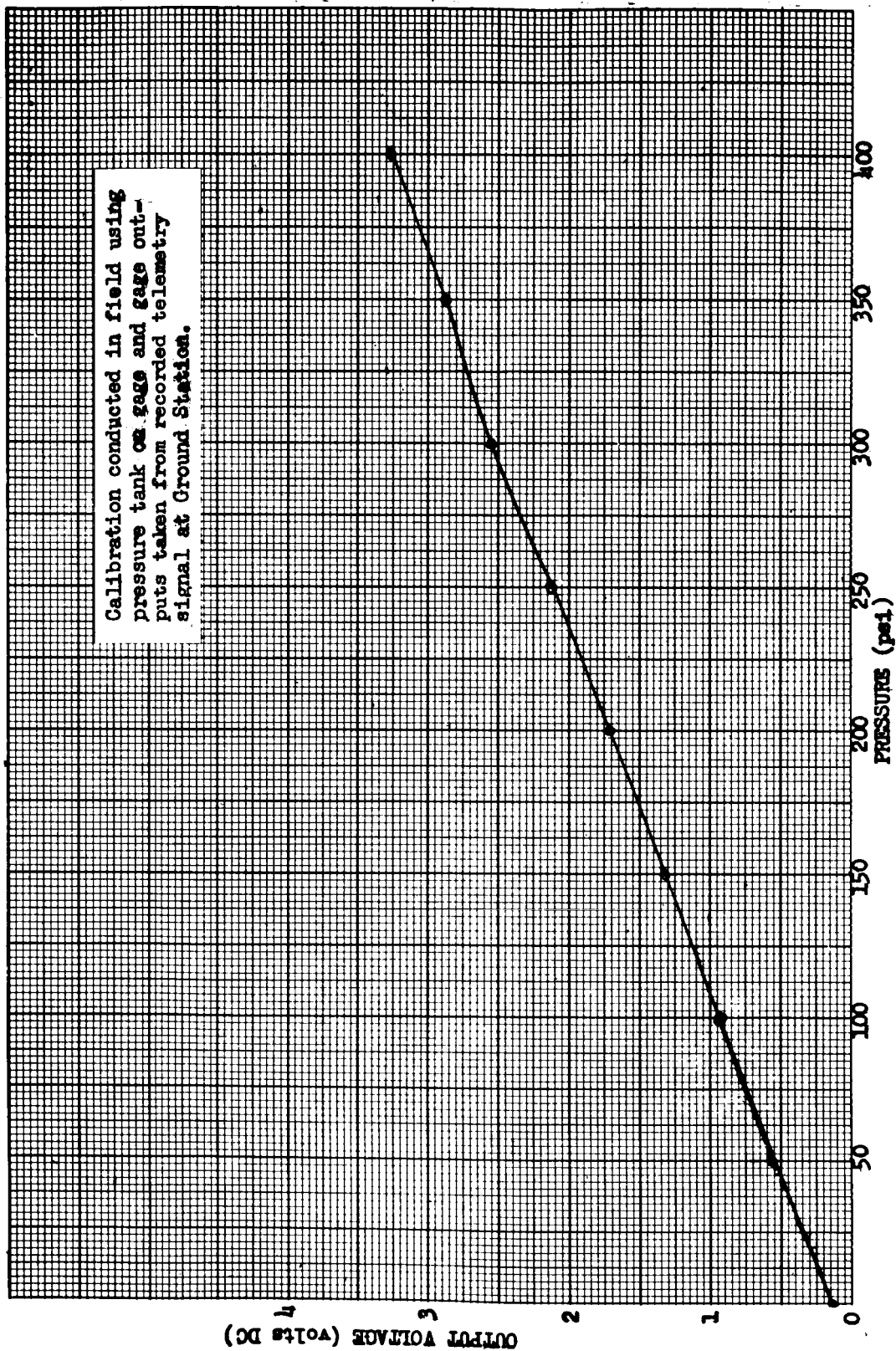


Figure A-3. Flight 4.107 GE Giannini Chamber Pressure (P_c) Gage, Model No. A-1.5160-20 (S/N 254-26) Calibration Curve

CALIBRATION DATA

HELIFLUX[®] MAGNETIC ASPECT SENSOR TYPE RAM-3

SERIAL NO 989

FIELD IN MILLIGAUSS	OUTPUT SIGNAL IN VOLTS D C	
600	<u>4.80</u>	
550	<u>4.62</u>	
500	<u>4.43</u>	
450	<u>4.23</u>	
400	<u>4.03</u>	
350	<u>3.82</u>	
300	<u>3.61</u>	
250	<u>3.40</u>	
200	<u>3.20</u>	
150	<u>2.99</u>	
100	<u>2.79</u>	
50	<u>2.60</u>	
0	<u>2.40</u>	(BIAS LEVEL)
-50	<u>2.20</u>	
-100	<u>2.01</u>	
-150	<u>1.81</u>	
-200	<u>1.60</u>	
-250	<u>1.39</u>	
-300	<u>1.18</u>	
-350	<u>.98</u>	
-400	<u>.77</u>	
-450	<u>.56</u>	
-500	<u>.36</u>	
-550	<u>+ .17</u>	
-600	<u>- .02</u>	



DIRECTION OF MAGNETIC FIELD FOR
VOLTAGE SIGNALS ABOVE BIAS LEVEL

NOTE:
CALIBRATION MADE WITH A 100K
OHM RESISTOR FROM SIGNAL
OUTPUT TO NEGATIVE TERMINAL
OF BATTERY SOURCE, AND A 100K
OHM RESISTOR FROM BIAS OUTPUT
TO NEGATIVE TERMINAL OF BATTERY
SOURCE

SCHONSTEDT INSTRUMENT COMPANY
SILVER SPRING, MARYLAND

CALIBRATION MADE WITH BATTERY SUPPLY OF 6.3 VOLTS DATE 4-11-63

Figure A-4. Calibration Data for Schonstedt Magnetometer
(S/N 989) for Flight 4.107 GE

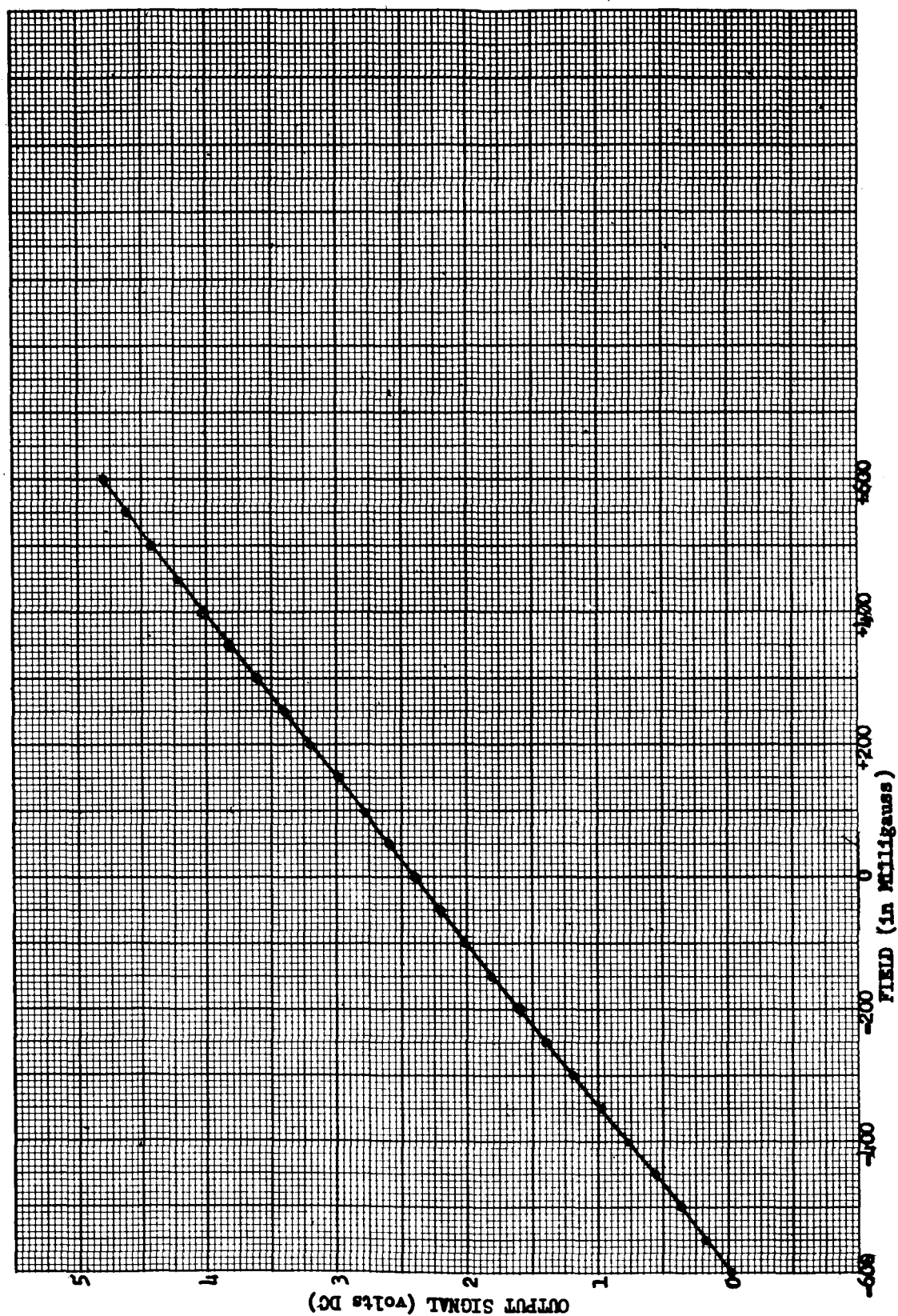


Figure A-5. Calibration Curve for Flight 4.107 GE Lateral Magnetometer, Schonstedt Type RAM-3 (S/N 989)

CALIBRATION DATA

HELIFLUX[®] MAGNETIC ASPECT SENSOR TYPE RAM-3

SERIAL NO 962

FIELD IN MILLIGAUSS	OUTPUT SIGNAL IN VOLTS D C	
600	<u>4.79</u>	
550	<u>4.60</u>	
500	<u>4.40</u>	
450	<u>4.20</u>	
400	<u>4.00</u>	
350	<u>3.80</u>	
300	<u>3.59</u>	
250	<u>3.39</u>	
200	<u>3.19</u>	
150	<u>2.99</u>	
100	<u>2.79</u>	
50	<u>2.59</u>	
0	<u>2.40</u>	(BIAS LEVEL)
-50	<u>2.20</u>	
-100	<u>2.01</u>	
-150	<u>1.81</u>	
-200	<u>1.61</u>	
-250	<u>1.41</u>	
-300	<u>1.20</u>	
-350	<u>1.00</u>	
-400	<u>.80</u>	
-450	<u>.60</u>	
-500	<u>.39</u>	
-550	<u>.20</u>	
-600	<u>+.01</u>	



DIRECTION OF MAGNETIC FIELD FOR
VOLTAGE SIGNALS ABOVE BIAS LEVEL

NOTE:
CALIBRATION MADE WITH A 100K
OHM RESISTOR FROM SIGNAL
OUTPUT TO NEGATIVE TERMINAL
OF BATTERY SOURCE, AND A 100K
OHM RESISTOR FROM BIAS OUTPUT
TO NEGATIVE TERMINAL OF BATTERY
SOURCE

SCHONSTEDT INSTRUMENT COMPANY
SILVER SPRING, MARYLAND

CALIBRATION MADE WITH BATTERY SUPPLY OF 6.3 VOLTS DATE 2-26-63

Figure A-6. Calibration Data for Schonstedt Longitudinal Magnetometer
(S/N 962) for Flight 4.107 GE

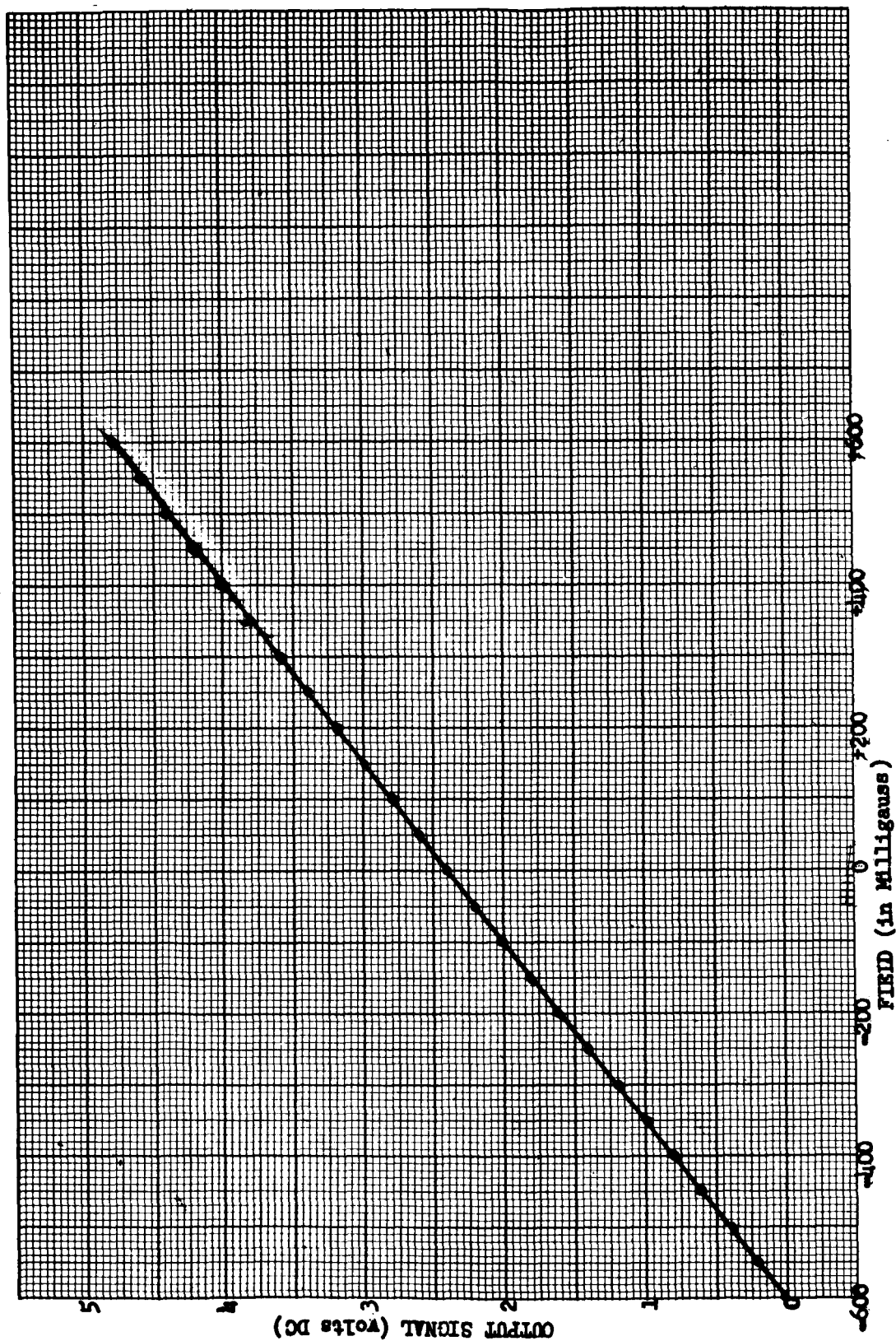


Figure A-7. Calibration Curve for Flight 4.107 GE Longitudinal Magnetometer,
Schonsted Type RAM-3 (S/N 962)

CALIBRATION DATA

HELIFLUX[®] MAGNETIC ASPECT SENSOR TYPE RAM-3

SERIAL NO 982

FIELD IN MILLIGAUSS	OUTPUT SIGNAL IN VOLTS D C
600	<u>4.82</u>
550	<u>4.63</u>
500	<u>4.43</u>
450	<u>4.23</u>
400	<u>4.03</u>
350	<u>3.83</u>
300	<u>3.62</u>
250	<u>3.41</u>
200	<u>3.21</u>
150	<u>3.01</u>
100	<u>2.81</u>
50	<u>2.61</u>
0	<u>2.41</u>
-50	<u>2.21</u>
-100	<u>2.01</u>
-150	<u>1.81</u>
-200	<u>1.61</u>
-250	<u>1.41</u>
-300	<u>1.20</u>
-350	<u>.99</u>
-400	<u>.79</u>
-450	<u>.59</u>
-500	<u>.39</u>
-550	<u>.19</u>
-600	<u>+ .00</u>

(BIAS LEVEL)



DIRECTION OF MAGNETIC FIELD FOR
VOLTAGE SIGNALS ABOVE BIAS LEVEL

NOTE:

CALIBRATION MADE WITH A 100K
OHM RESISTOR FROM SIGNAL
OUTPUT TO NEGATIVE TERMINAL
OF BATTERY SOURCE, AND A 100K
OHM RESISTOR FROM BIAS OUTPUT
TO NEGATIVE TERMINAL OF BATTERY
SOURCE

SCHONSTEDT INSTRUMENT COMPANY
SILVER SPRING, MARYLAND

CALIBRATION MADE WITH BATTERY SUPPLY OF 6.3 VOLTS DATE 3/26/63

Figure A-8. Calibration Data for Schonstedt Lateral Magnetometer
(S/N 982) for Flight 4.108 GE

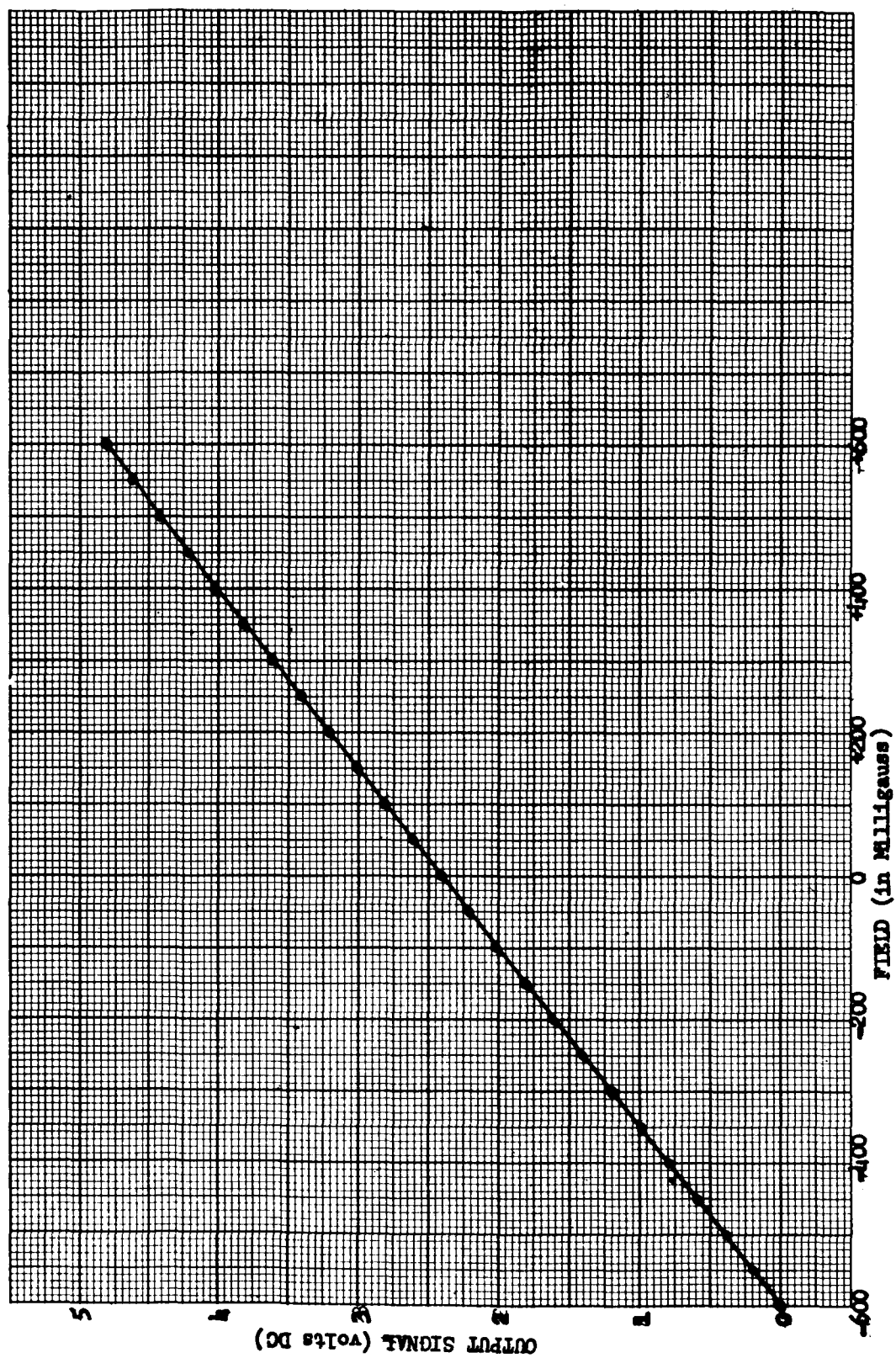


Figure A-9. Calibration Curve for Flight 4.108 GE Lateral Magnetometer, Schonsted Type RAM-3 (S/N 982)

CALIBRATION DATA

HELIFLUX[®] MAGNETIC ASPECT SENSOR TYPE RAM-3

SERIAL NO 981

FIELD IN MILLIGAUSS	OUTPUT SIGNAL IN VOLTS DC	
600	<u>4.82</u>	
550	<u>4.63</u>	
500	<u>4.44</u>	
450	<u>4.24</u>	
400	<u>4.04</u>	
350	<u>3.83</u>	
300	<u>3.62</u>	
250	<u>3.41</u>	
200	<u>3.20</u>	
150	<u>3.00</u>	
100	<u>2.80</u>	
50	<u>2.60</u>	
0	<u>2.41</u>	(BIAS LEVEL)
-50	<u>2.21</u>	
-100	<u>2.01</u>	
-150	<u>1.81</u>	
-200	<u>1.61</u>	
-250	<u>1.40</u>	
-300	<u>1.19</u>	
-350	<u>.99</u>	
-400	<u>.78</u>	
-450	<u>.58</u>	
-500	<u>.38</u>	
-550	<u>+.18</u>	
-600	<u>-.01</u>	



DIRECTION OF MAGNETIC FIELD FOR
VOLTAGE SIGNALS ABOVE BIAS LEVEL

NOTE:
CALIBRATION MADE WITH A 100K
OHM RESISTOR FROM SIGNAL
OUTPUT TO NEGATIVE TERMINAL
OF BATTERY SOURCE, AND A 100K
OHM RESISTOR FROM BIAS OUTPUT
TO NEGATIVE TERMINAL OF BATTERY
SOURCE

SCHONSTEDT INSTRUMENT COMPANY
SILVER SPRING, MARYLAND

CALIBRATION MADE WITH BATTERY SUPPLY OF 6.3 VOLTS

DATE 3/26/63

Figure A-10. Calibration Data for Schonstedt Longitudinal Magnetometer
(S/N 981) for Flight 4, 108 GE

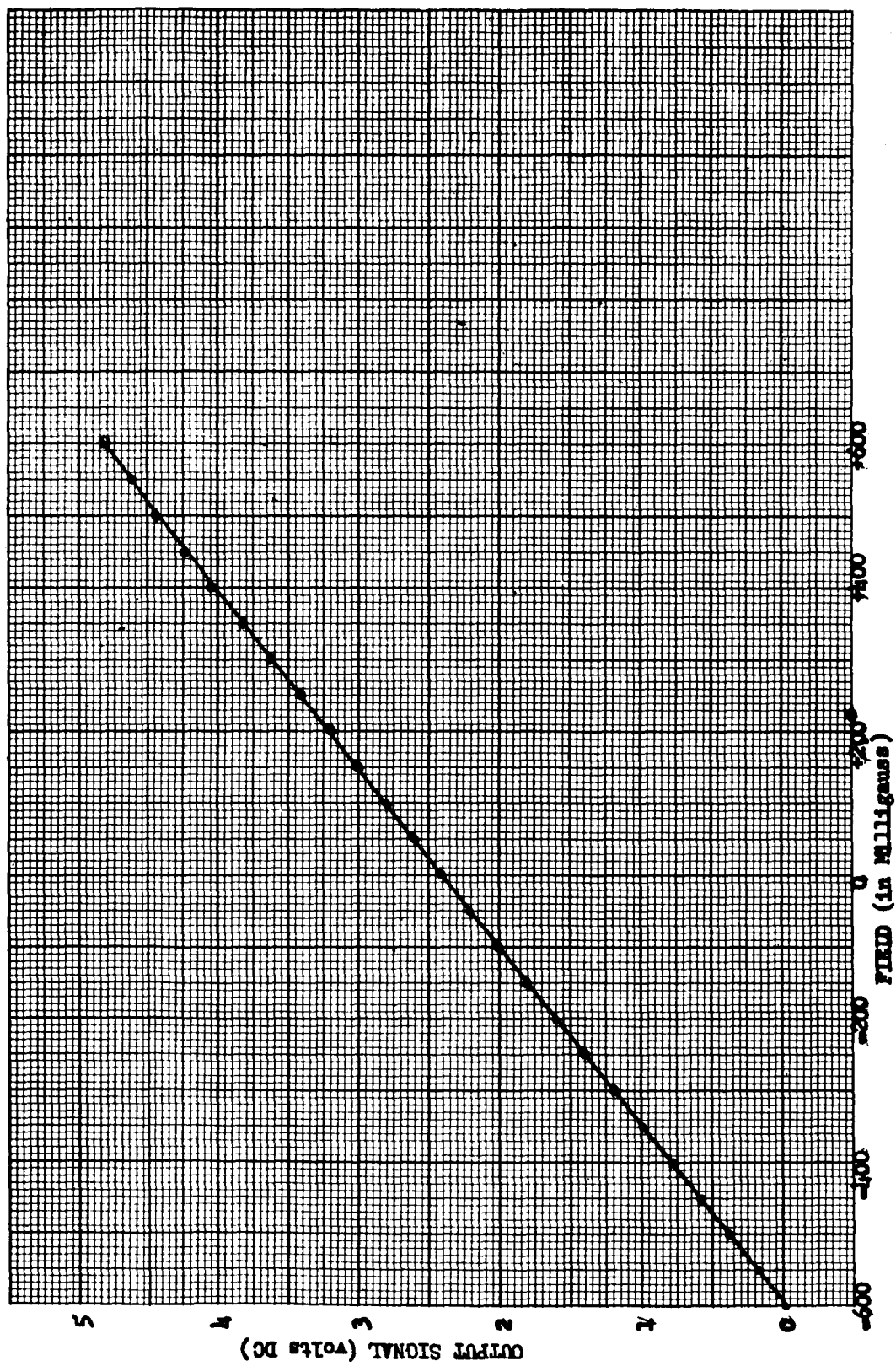


Figure A-11. Calibration Curve for Flight 4.108 GE Longitudinal Magnetometer,
 Schonstedt Type RAM-3 (S/N 981)

APPENDIX B

Appendix B contains information pertinent to range users intending to launch Aerobee payloads from the Churchill Research Range, Fort Churchill, Manitoba, Canada, and is a condensed extract from the range user's Document for Aerobee 4.107 GE and 4.108 GE, dated 10 July 1964.

1.0 GENERAL INFORMATION

1.1 Operations Command

The responsibility for launching test vehicles, acquiring telemetry and trajectory data during the flight of the test vehicle, processing of data, and insuring that safe operating conditions exist at all times is assigned to the Commander, CRR.

During the countdown and flight phase of the test vehicle, the Range Test Conductor (TC) will operate the Range Operations Conference (ROC) net and will coordinate all functions of the test with the proper section of Range Operations. The Range Test Conductor will have over all responsibility for all phases of the test, except Range Safety which is the responsibility of the United States Air Force and Canadian Army Safety Officers. The Test Conductor will relay all information which is of a useful and pertinent nature to the Range Safety Officer (RSO) and the Range User Mission Controller (MC). This information will include the countdown, system status information and the cause and duration of any holds which may occur during the test countdown.

The RSO will coordinate with the Pad Safety Officer (PSO) and the Flight Safety Officer (FSO) in carrying out his function and insuring that safe conditions exist during the countdown and launch of the test vehicle.

1.2 General Countdown

<u>Time</u>	<u>Event</u>
F-10 Day	Begin nose cone and test vehicle buildup.
F-5 Day	Nose cone horizontal checkout
F-3 Day	Final test vehicle checkout
F-1 Day	Test vehicle installed in launcher
	Nose cone vertical checkout
T-480	Begin fuel service
T-405	Fuel service complete
T-240	Acid service complete
T-210	Firing checks conducted
T-180	Final instrumentation check

T-150	Begin final arming
T-90	Final arming complete
T-60	Begin pressurization
T-45	Move tower to final launcher setting
T-35	Start final pressurization
T-10	Pressurization complete
T-5	Start final nose cone instrumentation check.
T-3	Top-off pressure tank and secure system
T-2	All Aerobee launch crew to fallback.
	Test vehicle and payload "GO"
T-15 sec.	Manual booster arming (if required)
T-0	FIRE
T+270 sec.	Sustainer apogee
T+450 sec.	Severance
T+540 sec.	Hard body impact

The payload will descend by parachute to a landing in Hudson Bay. Recovery will be accomplished from the water using two (2) aircraft furnished and operated by the RCAF. If the payload should land on a land area, recovery will be accomplished using a Range helicopter.

1.3 Test Vehicle Description

The Aerobee 150 Sounding Rocket is a free flight, liquid propellant test vehicle. The rocket is cylindrical in shape, 15 inches in diameter and 293.65 inches in overall length. Three fixed fins are mounted 120° apart on both the sustainer and the solid booster to provide aerodynamic stabilization. The sustainer stage itself consists of a helium pressure tank, a fuel tank, an oxidizer tank, a pressure regulator valve and other associated plumbing. The sustainer engine operates on a liquid propellant which is comprised of aniline (AFNA) and furfuryl alcohol for fuel and inhibited red fuming nitric acid (IRFNA) as the oxidizer.

The booster motor is a fin stabilized, expendable solid propellant rocket. It is cylindrically shaped, weighs 595 pounds, and is 74 inches in overall length. Both the sustainer and the booster are ignited simultaneously. The booster burns for 2.5 seconds and then, because there are no physical restraints between the sustainer and the booster, it separates because of drag and gravity forces and falls away.

The standard test vehicle has the following weights:

Sustainer (empty)	256	lbs.
Propellant and helium	<u>1075.8</u>	lbs.
Loaded weight without payload		1331.8 lbs.
Payload	123	lbs..
Nose cone	17	lbs.
Total sustainer and payload weight		<u>1463.8</u> lbs.
Booster Weight		<u>595.0</u> lbs.
TOTAL TEST VEHICLE LAUNCH WEIGHT		2058.8 lbs.

DIMENSIONS

Nose cone length	87.8	inches
Nose cone extension	<u>28</u>	inches
Total		115.8 inches
Sustainer length	191.8	inches
Booster length	83.5	inches
TOTAL VEHICLE LENGTH		391.1 inches
Body diameter	15	inches
Fin span	46.8	inches

General performance characteristics of the test vehicle are as follows: (For 87° launch elevation effective)

Booster burnout time	2.5 sec.
Sustainer burnout time	52.9 sec.

Sustainer burnout altitude	142,300 ft.
Sustainer burnout velocity	6800 fps
Time to apogee	240 sec.
Time to impact	540 sec.
Impact range	83 nautical miles
Apogee altitude	156 statute miles
Roll rate at burnout	2.0 rps

1.3.1 Transponders and Beacons

The range will furnish an AN/DPN-41 radar beacon and power supply which will be carried by each test vehicle. The Range will also provide and operate a radar beacon checkout console which will be used during the test countdown to perform the beacon checks.

Characteristics of the AN/DPN-41 beacon are as follows:

Receiver frequency range	2700 to 2950 Mc
Receiver sensitivity	-45 dbm

Type of signals receiver accepts to trigger transmitter:

Single pulse	0.25 u sec or greater duration
Double pulse	0.25 u sec duration with a pulse spacing of 3 u sec
Pulse rate acceptance	100 to 2500 pulses or groups of pulses per sec. More than 2500 pulses may cause countdown.
Transmitter Frequency	2700 to 2950 Mc
Transmitter peak power	50 watts minimum
Transmitter rf pulse width	075 u sec.

A SARAH beacon may be carried in the nose cone for aid in payload recovery. The beacon will transmit at a frequency of 243.0 Mc.

1.3.2 Command Control/Destruct System

No flight termination system or means of test vehicle destruction will be carried aboard the test vehicle.

1.3.3 Ordnance Items

A Beckman-Whitley destruction unit and 40 grain per foot primacord will be used to sever the payload and the recovery pack from the test vehicle. The device is operated by a G-timer and has a minimum fire current of one (1) amp and a maximum no-fire current of 50 micro amps. This device will also operate the parachute deployment mechanism.

The only other ordnance involved in the test vehicle is the solid booster and igniter.

1.4 Summary of Range Resources Utilization

1.4.1 Summary of Frequency Utilization

<u>Frequency</u>	<u>Class</u>	<u>Use</u>	<u>Transmitter Location</u>
155.01 Mc - 155.4 Mc	U	Mobile Radio	Various
166.425 Mc	U	Timing	Site 2
234.0 Mc	U	Telemetry	Test Vehicle
243.0 Mc	U	SARAH	Test Vehicle
*2700 Mc to 2950 Mc	U	Radar	Site 1
*2700 Mc to 2950 Mc	U	Beacon	Test Vehicle

This summary does not commit or dictate instrumentation for which frequencies are indicated.

* The specific radar or radars to be used on the test and the beacon and radar transmit frequencies will be determined by the Radar Superintendent. This information will be passed when authorized by the TC during the test countdown.

1.5 Range User's Responsibilities

The Range User is responsible for forwarding any changes in the following information to CHO, USAF/OAR, at least fifteen (15) days prior to the test day:

1. RF frequencies
2. Subcarrier frequencies
3. Subcarrier zero and five volt reference segments.

The Range User is also responsible for furnishing CHO a list of all Range User people who are authorized to request materials and support from the CRR.

The Range User is responsible for notifying CHO of any changes in the required services which are committed in paragraph #5.0 of this Operations Directive.

Frequency clearance for all airborne transmitter frequencies have been obtained. In the event of a change in an airborne transmitted RF frequency, the Range User is responsible for obtaining any necessary clearance for transmission on this frequency.

No digital clocks for countdown are available on the CRR and these will not be provided.

2.0 DATA AND DATA INSTRUMENTATION

2.1 Metric Data - General

All metric data produced by the systems on the CRR will be referenced to the system generating the data. Radar data is referenced to radar point-of-origin and sound ranging data is referenced to the microphone array. Conversion of this data to a cartesian coordinate system will be accomplished during the data reduction process.

2.1.1 Optics

No metric or engineering sequential photography is available at the CRR. For documentary optics coverage, see paragraph 2.4.

2.1.2 Pulse Radar

S-band radars will be used to satisfy the requirements for metric data during the flight of the vehicle. One S-band radar will attempt to lock on the airborne beacon prior to launch and will track the test vehicle from launch to loss of signal or impact. Another radar will use the MK-51 optical director as an acquisition aid to allow the radar to acquire skin track of the test vehicle as it emerges from the launcher.

The specific radars which will be used during the test will be designated by the CRR Radar Superintendent and this information will be passed to the Test Conductor during the test countdown. Radar beacon checks will be accomplished at the times indicated in the test master countdown and beacon "GO-NO-GO" status will be passed to the Test Conductor.

The Austin Model 100-A Automatic Data Recorder will be used as the recording source for providing radar metric data from launch to impact. The automatic data recorder will record target position, velocity components, and trajectory angles throughout the flight from both radars. Ten data points per second can be recorded on a time-shared basis between two radars having valid track of the test vehicle.

Real time present position of the test vehicle will be displayed on 30" x 30" plotting boards at the radar site. Target position will be plotted in the form of X versus Y and H versus R. Information from any radar having valid track of the test vehicle will be plotted.

Radar AGC voltages and "on target" indications will be recorded along with 2 pps timing on the MASSA 8-channel paper recorder used in conjunction with the Automatic Data Recorder.

2.1.3 Impact Location - Sound Ranging

The sound ranging system at Twin Lakes will be operated in an attempt to provide missile nose cone impact location information. Impact coordinates will be determined and furnished to the Range User if possible, however, because of the long range of the rocket and the trajectory which will be flown, no guarantee of impact data can be made.

2.2 Engineering Sequential Photography

(See Paragraph 2.4)

2.3 Telemetry

2.3.1 Equipment and Data Commitment

2.3.1.1 Equipment

The main telemetry station in the Operations Building at Launch, site #2, will be used to furnish telemetry coverage on this test along with the CRR backup telemetry station at Twin Lakes.

The following equipment at Launch will be used to provide

telemetry coverage on this test and to satisfy the Range User requirements:

- 5 Discriminators
- 1 Tri-helix Antenna
- 2 Receivers (1510-A or 1432)
- 2 Sanborn Recorders
- 2 Magnetic Tape Recorders (7-track)
- 1 CEC Oscillograph Recorder

Additional equipment may be used for backup purposes or to provide redundant coverage. Duplication of reception and recording is desirable to insure complete coverage.

The Range backup telemetry station at Twin Lakes will be operated on a best obtainable basis to cover any dropouts experienced at the primary station and to provide backup coverage in the event of a malfunction at the main telemetry station.

2.3.1.2 Data Commitment

Telemetry coverage will be provided from T-60 seconds to test vehicle impact.

2.3.1.3 Exceptions to the Range Users' Requirements - N.R.

2.3.2 Real Time Operating Requirements

2.3.2.1 Recordings

Two (2) 7-track magnetic tape recorders will be used to record telemetry information on these tests. This will provide backup coverage in the event of a recorder failure or malfunction. Two receivers will be used to record the telemetry signal. Only one (1) telemetry receiving antenna will be used.

The 7-track magnetic tape recorders will be set up with the following recordings made on the designated tracks:

Track	<u>Record</u>
1.	Voice annotation and 100 Kc reference
2.	Composite signal from receiver #1
3.	Signal strength from receiver #1
4.	Composite signal from receiver #2
5.	"Speedlock" tape speed control signal
6.	IRIG B timing

7. Signal strength from receiver #2

Signal strength of the received telemetry signal will be recorded from each of the two telemetry receivers using an FM subcarrier oscillator.

The tracks which are designated for recordings may be changed at the Range Users' request two (2) days in advance.

2.3.2.2 Calibration

11-point discriminator band limit calibration will be provided prior to and immediately following the flight of the test vehicle.

2.3.2.3 Real Time Recordings - Quick Look

Real time recording of all discriminator outputs will be made on the CEC oscillograph paper recorder. These will be available for quick look analysis within one (1) working day after the launch of the test vehicle.

2.4 Documentary Optics

8" x 10" still photography will be provided on call throughout the program for coverage of payload assembly, checkout and vehicle assembly.

16mm camera coverage of the launch phase will be provided.

3.0 SUPPORT INSTRUMENTATION

3.1 Communications - General

Communications between the compressor room, preparation area, blockhouse and launch bay will be provided by an intercom.

3.2 Radio

The Frequency Control and Analysis Facility will be available to monitor radio frequency transmissions during the test. UHF communications with the recovery aircraft will be available at radar.

3.3 Wire

3.3.1 MOPS

An intercom unit will be provided on the Users' console.

Presently, no digital clocks are available so only a standard 12 hour clock will be provided for the User. The Range User people in the launch bay and the compressor room will have communications with the MC on the Range User' net.

3.3.2 Telephone

An intercom system will be available to the User between the blockhouse, Prep Area and Launch Bay and Fallback Area.

3.3.3 Umbilical Cable

Conductors and terminal boxes between the launcher and the terminal box will be provided in a sufficient number to satisfy any requirements of the Range User. The instrumentation cable will consist of ninety-six (96) number six (6) wires which will terminate at junction boxes at the launcher bay and the blockhouse.

The Range User is required to furnish the cables to complete the connections in the blockhouse from the telemetry control console to the junction box and from the junction box in the Aerobee launch bay to the test vehicle. The cable required in the blockhouse should be about ten (10) feet in length.

3.4 Timing

Two different timing formats will be available for use during this test. These formats are:

IRIG Format B - 100 pps

IRIG Format C - 2 pps

Formats B and C are standard IRIG formats. IRIG Format C is 28-digit, 2 pps timing which is imposed on a 100 cps carrier. Format B is 36-digit, 100 pps timing imposed on a 1 Kc carrier.

The liftoff signal will be superimposed on the timing format and is identified by an increase in signal amplitude of about 100%. This liftoff signal will appear in this manner on each of the formats.

The 100 pps timing will be supplied to all magnetic tape records and the 2 pps timing may be supplied to any paper records.

Timing synchronization with WWV is accomplished using the WWV beat frequency comparator.

3.5 Sequencer

No sequencer will be used. The firing pulse will be initiated manually by the Range Test Conductor from the Test Conductor's console.

3.6 Visual Countdown and Status Indicators

No digital countdown clocks are available at this time. Only standard 12-hour electric clocks will be provided at the blockhouse. All sites will receive the verbal countdown from the Test Conductor.

3.7 Data Handling

All data produced by the CRR will be forwarded to CHOE. The Range User will receive the data from this agency.

3.8 Command Control/Supervisory Control

No command or destruct system is carried by the test vehicle and no command or supervisory instrumentation will be required during the test.

3.9 Other Support Instrumentation

The Range User will operate a telemetry checkout console in the blockhouse.

4.0 MATERIAL AND SERVICES

4.1 Services - General

4.1.1 Power

115-volt, 60-cps power will be provided in the nose cone preparation area and in the blockhouse. This will consist of one 30 amp service and three 15 amp services at the blockhouse.

4.1.2 Food Services and Accommodations

The Range will arrange for accommodations for the Range User people. The Range will also arrange for Launch Site food service. 24-hour notice of the number of meals required at the Launch Site by Range User people must be given. This information should be given to PAA Operations Manager, Phone Number 548.

4.1.3 Fire Protection

Normal fire support will be provided on the launch pad. In

addition, one fireman will stand by on the pad to support ordnance installation and other hazardous duties.

4.1.4 Medical Service

A First Aid Attendant and ambulance will be available 24 hours a day.

4.1.5 Guards and Security

The Range will provide guard service at the entrance to the launch area and will clear the area in accordance with the published Range Safety Plan at the time indicated in the launch countdown.

4.1.6 Pad Services and Engineering

Horizontal and vertical checks will be performed during the test countdown.

4.1.7 Water - N.R.

4.1.8 Survey - N.R.

5.0 TRANSPORTATION LOGISTICS

5.1 Surface

5.1.1 Personnel

Daily bus service is available from the base to the launch site and back.

"On call" taxi service will also be made available between launch site and the base on a 24-hour service. Two personnel carrying vehicles will be available for the use of the Range Users.

5.1.2 Cargo

CRR will provide for the unloading and transport of the vehicles and checkout equipment to the Range. CHO will be notified 24 hours prior to support time.

5.2 Air

5.2.1 Personnel

No Range User personnel can be authorized to accompany the RCAF aircraft to be used during the search and recovery operation.

5.2.2 Other

After recovery, the payload will be delivered to the Project Officer in the nose cone preparation area.

6.0 RECOVERY

6.1 Normal

During nose cone descent, at about 250,000 feet altitude, the aft initiator is fired, initiating the aft primacord. The primacord separates the payload from the test vehicle. The payload will then tumble in a flat spin attitude until an altitude of about 18,000 feet is reached, at which the parachute deployment sequence begins. The pilot chute is deployed to stop payload tumbling. The main chute is then opened, decelerating the payload to a mean descent velocity of 25 feet per second.

The payload will contain the following recovery aids:

- A. A SARAH beacon which will transmit on a frequency of 243.0 Mc and furnish a homing signal for the recovery aircraft.
- B. An S-band Radar beacon to furnish final impact location information from radar.

7.0 DATA PROCESSING AND DISPOSITION

7.1 General

All data produced by the Churchill Research Range will be turned over to CHOE. The Range User will obtain all data from CHOE.

7.2 Disposition of Processed Data				
DATA DESIGNATION	FORM	COPY	RECIPIENT	DELIVERY TIME
7.2.1 Metric Data				
1*19.2.1(2)	Plotting Board Chart	Orig.	AFCRL	T+24 hrs
1*19.2.2(2)	"	1	"	T+24 hrs
1*19.2.1(1)	"	Orig.	"	T+24 hrs
1*19.2.1(2)	"	1	"	T+24 hrs
1*19.1(1)	Mag. Tape	Orig.	"	8-10 wks
1*19.1(1)	"	"	"	8-10 wks
3.3.1.1(1)	Impact Co-ordinates	"	"	T+18 hrs
7.2.2 Documentary Data				
4.2.6	Photographic Prints	Orig.	"	+ 20 W.D.
4.2.7	Still Photo Prints	Orig.	"	+ 20 W.D.
4.2.5.1(1)	Motion Picture Film	"	"	+ 20 W.D.
7.2.3 Telemetry Data				
5.2.1.1(2)	Mag. Tape	"	"	Original to be reduced and forwarded in approximately 10 weeks
5.2.1.2(2)	"	1	"	+ 2 W.D.
5.2.4.1(1)	Quick Look Oscillograph Paper Record	Orig.	"	T+2 days
7.3 Meteorological Data				
6.2.8.6(7)	Meteorological Report	Orig. & 6 copies	"	+ 2 W.D.
7.4 Transportation Reports - N.R.				

8.0 FACILITIES

8.1 Facilities - General

(1) Storage for equipment crates of about 200 square feet will be provided.

(2) A preparation area of about 300 square feet for nose cone assembly and checkout will be provided. A rope hoist or equivalent, capable of lifting 500 lbs. will be provided by the Range.

(3) A hazardous storage area for the motor, igniter and squib will be provided.

(4) Space will be provided for the payload checkout console.

9.0 RANGE SAFETY

9.1 Range Safety Officer's Responsibilities

Overall range safety is the responsibility of the United States Air Force and Canadian Army Safety Officers. Final approval for firing will rest with the Range Safety Officer (RSO). The RSO will coordinate with the Pad Safety Officer (PSO) and the Flight Safety Officer (FSO) in carrying out his function and insuring that safe conditions exist during the countdown and launch of the test vehicle. If, after evaluating the inputs available to him, the RSO feels that safety of personnel or equipment would be endangered, he has the responsibility of calling a hold at any time during the range countdown. The countdown will not be resumed until clearance to proceed has been given by the RSO. Canadian Safety Officer has final NO-GO authority.

8.2 Pad Safety Officer's Responsibilities

The Pad Safety Officer (PSO) is the Range Safety Officer's representative in the launch area complex. He is responsible for coordinating and enforcing range safety policy and keeping the RSO informed of all activities carried on at the launch complex. Any checks, procedures, or lack of such which will result in the degradation of overall safety, will be immediately brought to the attention of the RSO.

9.3 Flight Safety Officer's Responsibilities

The Flight Safety Officer (FSO) is the Range Safety Officer's representative responsible for surveillance of air and sea areas before and during the conducting of test vehicle operations. In accomplishing this duty, the FSO will work in close coordination

with RCAF, CA(R), and DOT personnel. If, at any time, air or sea traffic is such that there is danger to personnel or equipment, the FSO will so inform the RSO who may take action to halt the countdown. The FSO is also responsible for verifying that the missile impact occurs within the Range boundaries.

The FSO will also monitor all functions of the recovery operation and ascertain that no unsafe procedures are used during this operation.

9.4 Safety Criteria

(1) Pad Safety

When Range User personnel are required to participate in the preparation of a vehicle for launch, such personnel will adhere in every aspect to the established safety procedures. The Range User will ensure that only essential personnel are present in the launch area and that these personnel will comply with directives issued by the Pad Safety Officer in the interests of pad safety.

(a) The Pad Safety Officer will ensure that the number of personnel in the launch area is kept to a minimum consistent with safe operations.

(b) He will ensure that fire support is standing by during propellant transfer to or from storage tanks, while propellants are aboard a liquid-propellant vehicle, and when a solid propellant vehicle is within the area and work is being performed upon it.

(c) The Pad Supervisor will maintain close coordination with the Test Conductor concerning policies and procedures and will notify him immediately of any handling malfunction or other incident creating or contributing to a hazardous condition. He will call for a hold in the countdown when such action is in the interest of safety or reliability, or when difficulty is encountered in the preparation of the vehicle for launch.

(d) He will be responsible for the inspection and monitoring of electrical connection of all pyrotechnics with the launch area.

(e) Whenever a vehicle is raised from a horizontal position to the specified elevation for launch, all non-essential personnel will leave the launch area while this work is being performed.

(f) During squib installation, Pad Safety Officer and Pad Supervisor will be the only personnel in the launch area. After installation, the Pad Safety and Pad Supervisor will personally verify to Range Safety that the launch area is clear of all personnel. Failure to do this will stop the countdown.

(g) After the Pad Safety Officer reports the launcher is clear, no person will be allowed to leave the blockhouse unless specifically authorized by the Range Safety Officer.

NOTE: Visual warning devices are not installed.

(2) Flight Safety

(a) Mandatory "NO-GO"

- (1) Anytime predicted impact is not within the Range boundary.
- (2) Anytime there is no way to verify impact.
- (3) Surveillance radar is ineffective.
- (4) Aircraft on the Range.

(b) Recommended "NO-GO"

- (1) Sound ranging ineffective, one tracking radar operational without beacon and optics are ineffective, because of low ceiling and/or poor visibility.

(c) Marginal conditions for "GO" - "NO-GO"

- (1) Sound ranging ineffective, one radar in with operational radar beacons, but, ineffective optics.

(d) Low ceiling is 1,500 feet or below and poor visibility exists when the launch area is not visible through the optical tracker from radar.

(3) Range Safety

The Range Safety Officer's decision to launch can be overruled by the Canadian Safety Officer.